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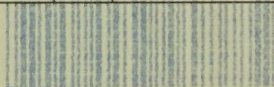
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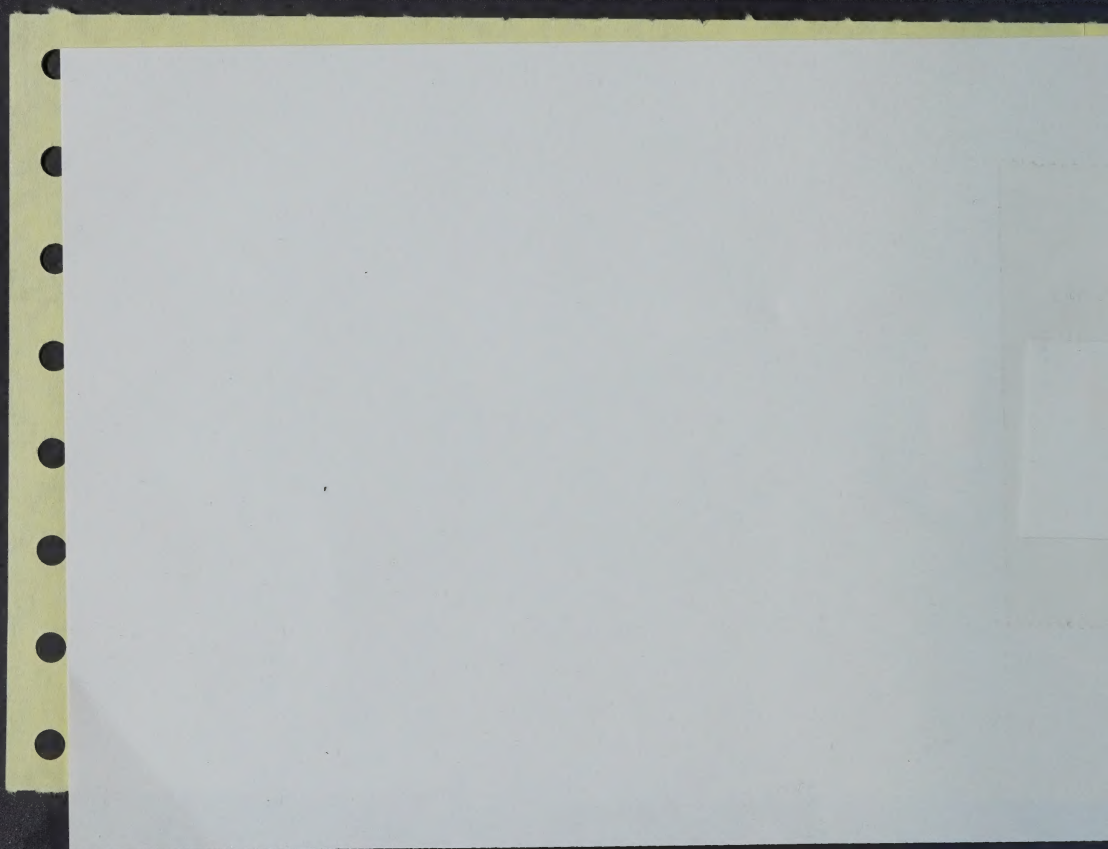
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RATIONAL DICTIONARY

of

FRENCH ARCHITECTURE

From XI to XVI Centuries

29

EUGENE EMANUEL VIOLETTE-LE-DUC

Government Architect

Inspector General of Diocesan Edifices

Volume IV

From ~~Dais to Ent~~

Construction to cymberium

PARIS

Translated by N. Clifford Ricker. D. Arch

Emeritus Professor of Architecture

UNIVERSITY OF ILLINOIS

Urbana, Ill.

1919

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OF

FRENCH ARCHITECTURE

From XI to XVI Centuries

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EUGENE EMANUEL VIOLET-LE-DUC

Government Architect

Inspector General of Diocesan Buildings

Volume IV

From 1515 to 1547

Constitution to Cyclopedia

PARIS

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## CONSTRUCTION. Aperçu general. Construction. General

Construction is a science; it is also an art, i.e., there is necessary for the construction knowledge, experience and a natural faculty. One is born a constructor, the science acquired can only develop the germs deposited in the brains of men destined to give utility and a durable form to the raw material. It is with peoples as with individuals; some are constructors from their cradles, others never become such; to the progress of civilization adds but little to that native faculty. Architecture and construction must be taught or practised simultaneously; construction is the means, architecture is the result, yet there are architectural works that cannot be regarded as constructions, and there are certain constructions that cannot be placed in the number of architectural works. Some animals build, some cells and others nests, halls, galleries, a sort of nests, nets of threads; these are indeed structures, but are not architecture.

To construct for the architect is to employ the materials according to their qualities and their natures, with the preconceived idea of satisfying a need by the simplest and most substantial means, to give to the structure the appearance of durability, suitable proportions subject to certain rules imposed by the senses, reason and human instinct. The methods of construction must then vary according to the nature of the materials, of the means at disposal, the needs to be satisfied, and the civilization within which it is produced.

The Greeks and Romans were constructors; yet these two peoples started from opposed principles, have not employed the same materials, placed them in the work by different means, and satisfied requirements that were not the same. So the appearance of the Greek and that of the Roman monument differed essentially. The Greek employed only the lintel in his structures; the Roman used the arch and consequently the vault; that alone indicates sufficiently how these opposed principles must produce very dissimilar structures, both for the means employed and for their appearance. We do not have to make known here the origins of these two principles and their results; we shall take Roman architecture at the point attained by it in the last time of the empire, for that is the only source from which the middle ages first borrowed.

...the first time of the empire, for that is the only  
...we shall take Roman architecture at the point attained  
...when were the origins of these two principles and their res-  
...in employed and for their appearance. We do not have to make  
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...appearance of the Greek and that of the Roman architecture differed  
...and satisfied requirements that were not the same. To the ex-  
...treme catastrophe, placed them in the work in different ways,  
...one started from general principles, and not satisfied the  
...The Greek and Roman architecture was based on the same  
...and the civilization which it is produced.

...of the mass at disposal, the needs to be satisfied,  
...construction must then vary according to the nature of the im-  
...posed by the masses, reason and human instinct. The methods of  
...formal, suitable proportions subject to certain rules in-  
...structural laws, to give to the structure the appearance of  
...convenient use of satisfying a need by the simplest and most  
...adaptation to their qualities and their natures, with the crea-  
...to manufacture for the architect is to employ the materials

...structures, but are not architecture.  
...definition, a sort of nests, nests of tabernacles: these are indeed  
...the, some materials built, some cells and others nests, halls,  
...lines must be placed in the number of architectural vo-  
...as regarding as constructions, and there are certain construc-  
...in its own right." (The Architectural Theory of the Middle Ages)

...directly and necessarily; construction is the means, architecture  
...locality, topography and construction must be taken on pre-  
...the difference of civilization adds but little to that native  
...constructures from their origin, others never become such; it  
...material. It is with peoples as with individuals; some are  
...and destined to give utility and a durable form to the var-

...lived and only few of the forms decorated in the plains of  
...a general tendency. We have a number of examples of the same ten-

...at the origin of the architecture, architecture is the means, architecture

The principle of Roman construction is this; to establish points of support presenting by their position and perfect cohesion masses sufficiently stable and homogeneous to resist the weight and thrust of vaults; to distribute these loads and thrusts to fixed piers, whose inert resistance is sufficient. Thus Roman construction is only skilfully calculated solid masses, all whose parts are without elasticity and maintain themselves by the laws of gravity and their perfect adhesion. Among the Greeks stability is obtained only by judicious observation of the laws of gravity; they did not seek for the adhesion of materials; in a word, they neither knew nor employed mortars. In their monuments the loads only acting vertically, they needed only vertical resistances, vaults being unknown to them, they did not have to resist inclined pressures, which are termed thrusts. How did the Romans proceed to obtain passive resistances and perfect adhesion of all the inert parts of their structures and the active parts, i.e., between the points of support of the vaults? They constructed homogeneous masonry of small materials, pebbles or stone chips joined by excellent mortar, enclosing this concrete within facing bricks, rubble or cut stones. As for vaults, they formed these on centerings by means of brick or stone arches and concrete tamped on wooden lagging. This method presented numerous advantages; it was rapid; it permitted the construction of edifices on the same plan in all countries; employing soldiers or levies to erect them; it was durable and economical; only required good direction, demanding but a limited number of skilful and intelligent workmen, under whom could labor a considerable number of mere laborers; it avoided the slow and difficult transportation of materials of great size, and of machines to hoist them; finally it was the result of the social and political state of Roman society. Yet the Romans erected edifices in imitation of the Greeks, like their temples and basilicas; but these monuments are an importation, and must be placed outside true Roman construction.

The barbarians that invaded the Roman provinces did not bring with them arts and methods of building, or at least the elements introduced by them into the midst of expiring Roman civilization could have but a very weak influence. They found the monuments built and used them. Long after the invasion of

The stability of Roman construction is based on the use of concrete, which is a material of great strength and durability. The Romans were the first to use concrete in the form of a solid mass, and they were the first to use it in the form of a vaulted structure. The Romans were also the first to use concrete in the form of a wall, and they were the first to use it in the form of a column. The Romans were the first to use concrete in the form of a floor, and they were the first to use it in the form of a roof. The Romans were the first to use concrete in the form of a bridge, and they were the first to use it in the form of a tunnel. The Romans were the first to use concrete in the form of a fortification, and they were the first to use it in the form of a city wall. The Romans were the first to use concrete in the form of a palace, and they were the first to use it in the form of a temple. The Romans were the first to use concrete in the form of a church, and they were the first to use it in the form of a cathedral. The Romans were the first to use concrete in the form of a school, and they were the first to use it in the form of a university. The Romans were the first to use concrete in the form of a hospital, and they were the first to use it in the form of a prison. The Romans were the first to use concrete in the form of a factory, and they were the first to use it in the form of a warehouse. The Romans were the first to use concrete in the form of a ship, and they were the first to use it in the form of a lighthouse. The Romans were the first to use concrete in the form of a clock, and they were the first to use it in the form of a watch. The Romans were the first to use concrete in the form of a calendar, and they were the first to use it in the form of a map. The Romans were the first to use concrete in the form of a book, and they were the first to use it in the form of a letter. The Romans were the first to use concrete in the form of a poem, and they were the first to use it in the form of a story. The Romans were the first to use concrete in the form of a play, and they were the first to use it in the form of a movie. The Romans were the first to use concrete in the form of a song, and they were the first to use it in the form of a dance. The Romans were the first to use concrete in the form of a game, and they were the first to use it in the form of a sport. The Romans were the first to use concrete in the form of a religion, and they were the first to use it in the form of a philosophy. The Romans were the first to use concrete in the form of a science, and they were the first to use it in the form of a technology. The Romans were the first to use concrete in the form of an art, and they were the first to use it in the form of a literature. The Romans were the first to use concrete in the form of a history, and they were the first to use it in the form of a geography. The Romans were the first to use concrete in the form of a politics, and they were the first to use it in the form of a economics. The Romans were the first to use concrete in the form of a social, and they were the first to use it in the form of a culture. The Romans were the first to use concrete in the form of a family, and they were the first to use it in the form of a community. The Romans were the first to use concrete in the form of a nation, and they were the first to use it in the form of a world. The Romans were the first to use concrete in the form of a universe, and they were the first to use it in the form of a everything.

the barbarians on Gallo-Roman soil, there still existed a great number of antique edifices; which indicates that the German hordes did not destroy all. They frequently even attempted to repair, and soon to imitate them.

But after such long disasters, the traditions left by Roman constructors must have been lost in great part; under the Merovingians the edifices erected in Gaul were only barbaric reproductions of antique structures spared by war, or that had been able to resist long abandonment. The few monuments remaining to us, preceding the Carlovingian period, present to us only structures in which is only perceived a pale reflection of the art of the Romans, rude imitations of the edifices, whose numerous remains still cover the soil. Only under the reign of Charlemagne did men see constructors make some attempts to escape from the ignorance in which the preceding centuries were plunged. The relations with the East maintained by that prince, his connections with the Lombards, among whom the last traditions of antique art seem to have taken refuge; supplied him with the means of attracting to him and into countries subject to his rule, constructors that he knew how to utilize with zeal and remarkable perseverance. His purpose certainly was the cause of the revival of the Roman arts; but the sources from which he must draw to attain that result were profoundly modified in their principles. Charlemagne could not send architects to study the monuments of old Rome, since he had none; he could only demand artists, geometers and skilful workmen from the East, Spain or Lombardy, countries alone possessing them. These brought with them methods already far removed from those of antiquity. The Carlovingian renaissance then produced results very different from what its author probably expected from it. After all the purpose was attained, since the new elements imported into the West soon produced considerable efforts, and from that epoch the arts rapidly progressed. The history of that advance from the point of view of construction alone, we shall attempt to write, referring our readers to Art. Architecture for all pertaining to the development of that art from the 10<sup>th</sup> to the 16<sup>th</sup> centuries.

During the duration of the Roman empire, either at Rome or at Byzantium, it is easy to recognize that the vaults were the dominant preoccupation of constructors. From the tunnel

[illegible]

vault they passed quickly to the cross vault, and from the dome borne on a circular wall or drum, they had reached in the construction of S. Sophia the hemispherical vault resting on pendentives; an immense step, that established a sharp line of separation between the Roman structures of antiquity and those of the middle ages. Neither Rome nor Italy, nor Gaul showed a single Roman edifice in which the hemispherical vault was borne by pendentives. The church of S. Sophia is the first that furnishes us with an example of that sort of construction, and as everyone knows, it is the largest dome in existence. How did Roman architects established in Byzantium come to conceive and execute a construction of that kind? That is what we shall not seek to unravel. We shall take the fact, where for the first time it appears with an incontestable grandeur of freedom. To cover a circular enclosure by a hemispherical vault was a very natural idea, that was adopted from high antiquity; to cause the penetration of cross vaults into the circular drum was an immediate result of that first step. But to erect a hemispherical dome on a square plan, i.e., on four isolated piers set at the corners of a square, was no longer a deduction from that primary principle, but an innovation and one of the boldest innovations.

Yet the constructors brought by Charlemagne from Lombardy and the East to the West did not bring with them that mode of construction; as at Aix-la-Chapelle, they were satisfied to erect vaults with octagonal or circular bases on drums rising from the ground. It was only later that derivatives from Byzantine construction had direct influence in the West. As for the methods of building the Carolingian structures, they approached Roman methods, i.e., consisted of masses of concrete enclosed in facings of bricks, rubble or cut stone, or again of rubble alternating with courses of bricks, the whole retained by thick mortar joints, as shown in Fig. 1.

We indicate at A the courses of triangular bricks presenting the longer sides at the surface, and at B the course of rubble scarcely regular and presenting their frequently square faces at the surface. At C is represented a brick with a thickness varying from 1.6 to 2.0 ins, and at D a piece of facing rubble. This was merely a rudely executed Roman structure. But the Romans rarely employed this method except when they desired

veals they seemed united to the other vessels, and from the  
fact that on a certain wall or base, they had covered the  
the disposition of it. Again the transverse wall resting  
on posteriorly; at present, that indicated a more il-  
lustration of the same structure of anteriorly  
and those of the middle wall. Further down the wall, the  
fact showed a single lower portion in which the transverse  
wall was borne by posteriorly. The character of the wall is a  
the first that indicated as with an example of that part of  
consequently, not an evidence of it. In the lateral wall in  
existence. For its own structure indicated in the middle  
wall as connected and showed a continuation of that wall and  
is that as well as seen in vertical. The wall was the fact,  
where for the first time it appeared with an irregularity in  
nature of the wall. To cover a circular structure as a feature  
circular wall. A very natural idea, that was suggested from  
side continuity; to cover the penetration of cross walls into  
the circular drum was an immediate result of that fact alone.  
The correct a hemispherical dome on a square plan, i.e., on  
four inclined planes set at the corners of a square, was no  
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Yet the construction proposed by the architect from the  
fact that the fact did not bring with them that mode of  
construction; as at Aix-la-Chapelle, they were satisfied to  
build walls with occasional or vertical lines as better tried  
from the ground. It was only later that the architect from the  
also construction and direct influence in the fact, as for  
the schools of building the Gothic style structure, they co-  
sidered Roman methods, i.e., instead of domes of concrete  
concrete in sections of blocks, to be in one, or again  
of rubble masonry also courses of blocks, as with the  
led by thick mortar joints, as shown in Fig. 1.

We indicate at A the courses of triangular bricks representing  
the joints either at the surface, and at B the courses of tri-  
angularly shaped and projecting bricks frequently shown  
from at the surface. At C is represented a wall with a rib-  
bing varying from 1/2 to 1/4 inch, and at D a series of facing  
bricks. This was really a fairly excellent Roman structure. But  
the Roman rarely employed the method shown when they desired

to cover the surfaces with marble slabs or stucco; if they made the facings of cut stones, they set these with dry joints without mortar and on their quarry beds, and left them large beds, so that the facings should actually become a reinforcement capable of resisting a pressure, that the concrete mass alone could not have borne.

From the first times of the Carlovingian epoch, the constructors also desired to erect structures faced with cut stone in imitation of certain Roman structures; but they did not dispose of the powerful means employed by the Romans; they could neither transport nor indeed raise to a certain height blocks of stone of great volume. Thus they were satisfied with the appearance, i.e., they arranged surfaces formed of facings of stones set on edge and most frequently of small thickness, carefully avoiding holes and filling the spaces felt between these surfaces by small stones sunk in mortar. They sometimes went so far as to desire to imitate Roman bonded construction by setting thick stone facings with dry joints without mortar. It is unnecessary to state how vicious is this construction, the more so because their mortar being mediocre, their lime badly burned or slaked, their sand dirty and the concrete extremely irregular. Also sometimes they took a middle course, i.e., they constructed the faces of small cut stones joined by thick beds of mortar.

These attempts and experiments did not constitute an art. If in the details of the construction the architects exhibited very moderate skill, if they could only imitate badly the Roman procedures, with greater reason in the entirety of their structures they found themselves constantly attacked by difficulties, that they were not in condition to solve; lacking knowledge and possessing only almost effaced traditions, having neither skilful workmen nor powerful machines, proceeding by groping, they must make, and did make unheard efforts to erect edifices of small dimensions, to make them stable, especially to vault them. Then in Carlovingian monuments one always recognizes the insufficiency of the constructors, where one can prove their embarrassment, uncertainty, and often that discouragement produced by lack of power. Even from that ignorance of the antique procedures, and especially from the constant efforts of the constructors of the 9th and 10th centu-

to cover the surfaces with marble slabs or mosaic; if they made the facades of our houses, they set these with dry joints without mortar and on their country cells, and left them bare, so that the facades would actually become a relief-work of sculpture of a grotesque, but the grotesque was alone could not have done.

From the first times of the Christian era, the concrete was also decorated at great distances from the walls, in imitation of marble, from the beginning; but only did not appear of the marble which was used by the Romans; some of the marble facades were indeed taken in a certain number of cases of great value. These were very beautiful and the appearance, a very simple and elegant (type of facade) of houses and in which the beauty of walls, facades, especially in the case of the houses built between the middle and the end of the 15th century. They sometimes used small stones such in mortar. They sometimes used to be so as to desire to imitate Roman bonded construction by setting into stone facades with the joints without mortar. It is unnecessary to state that this is also the case in the case of houses built in the 16th century, their time of the house as because their mortar being mediocre, their time of being burned or slaked, and their sand dirty and the concrete extremely irregular. Also sometimes they took a middle course, i.e., they constructed the face of walls and houses from the same kind of concrete.

These attempts and experiments did not constitute an art. It is the result of the construction and the materials which are very numerous, and they could only imitate partly the Roman procedure, with greater success in the case of the facades. They found themselves constantly attacked by difficulties, that they were not in contact or rather, lacking knowledge and possessing only a few elements of the art, they were obliged to use the most simple and most useful machines, and by the way, they were not able to make much effort in the construction of walls, facades, to make them better, and finally to make them. They used the Christian architecture and have sometimes the imitation of the architecture, some one has given their attention, sometimes, but other than the ornamentation of the facade of houses, and the ornamentation of the facade of houses, and the ornamentation of the facade of houses.

centuries there came a new art of building; the result of experiences unfortunate at first, but which were repeated with perseverance and a constant improvement, traced a new path not before marked out. No less than three centuries were necessary to instruct these barbarians; still after such slow efforts, they could flatter themselves with having opened to future constructors a new era, that received but little from the arts of antiquity. The imperative necessities by which these primitive constructors found themselves confronted compelled them to seek resources in their own observations, rather than in the study of the monuments of antiquity, which they knew but very imperfectly, and that in most provinces of Gaul no longer existed except in the state of ruin. Besides, being ready to adopt foreign products, they subjected them to imperfect procedures, and thus transforming them, made them concur in an art wherein reasoning entered more than tradition. That school was hard; only based uncertainly on the past, finding themselves facing the needs of a civilization in which all was to be created, possessing only the elements of the exact sciences, it had no guide other than the experimental; but that method, if not the most rapid, at least has the advantage of training observing practitioners, careful to combine all the improvements that can aid them.

Already in the edifices of the 11th century construction is seen to make sensible progress, that is only the result of faults avoided with more or less skill; for error and its effects instruct men more than perfect works. No longer disposing of the active means employed by the Romans in their constructions; lacking men, money, transportation, connections, roads, tools and machines; confined within provinces separated by the feudal rule, constructors could only count on very weak resources, and yet already at that epoch (11th century), they were required to erect vast monasteries, palaces, churches and ramparts. It was necessary for their industry to supply all that Roman genius could organize, all that our modern civilization furnishes us with profusion. It was necessary to obtain great results at small cost (for then the West was poor), to satisfy numerous and pressing needs on a soil ravaged by barbarians. It was necessary for the constructor to seek materials, occupy himself with the means of transporting them,



combat the ignorance of unskilful workmen, for himself to make observations on qualities of lime, sand and stone, to provide timber; he must not only be the architect, but also quarryman, draftsman, stonecutter, foreman, carpenter, lime-burner, mason, able to aid himself only by his intelligence and his reasoning as an observer. It is easy today for us, when a notary or a merchant builds himself a house without the help of the architect, to regard as rude these first attempts, but the total of the genius then necessary to the constructors to erect a hall or a church was certainly superior to what we demand from an architect of our time, who can build without knowing the primary elements of his art, as too frequently occurs. In those times of ignorance and of barbarism, the most intelligent and those elevated above the common workman were alone capable of directing a structure; and the direction of buildings, necessarily limited to a restricted number of superior men, must thereby produce original works, in the execution of which reasoning enters for a great part; where calculation is apparent, and whose form is clothed by that distinction that is the particular character of reasoned constructions, subjected to the needs and customs of a people. Indeed it is necessary to recognize, unless we ourselves must be designated as barbarians, that the beauty of a structure does not consist in the improvements made by a very developed civilization and industry, but in the judicious use of materials and of means placed at the command of the constructor. With our so numerous materials, the metals supplied by our mills, the skilful and innumerable workmen of our cities, we erect a vicious structure, absurd, ridiculous, without reason or economy; while with rubble and wood may be built a good, beautiful and wise structure. So far as we know, never has the variety nor the perfection of the material employed been the proof of the merit of its employer; excellent materials are detestable if placed in the work away from the place to which their function is adapted, by a man without knowledge and sense. What one should be proud of is the good and proper use of the materials, and not the quantity or quality of these materials. This is stated as a digression, to engage our readers not to scorn constructors, who have at command only badly quarried stone, bad rubble collected from the ground, poorly



turned lime, imperfect tools and weak machines; for with such rude elements those constructors can teach us excellent principles, applicable at all times. And the proof that they can do so is that they formed a school, which from the point of view of practical or theoretical science, the judicious use of materials, has reached a degree of perfection not surpassed in modern times. It is permissible for those who teach architecture without having practised the art, to judge of the architectural productions of ancient and modern civilizations only by appearance, a superficial form that seduces them; but for us called to construction, it is necessary for us to seek our instruction from the experiments and the progress of those ingenious architects, who start from nothing and have everything to do to solve the problems set by the society of their time. To regard the mediæval constructors as barbarians, because they must renounce construction by employing the methods of the Romans, is not to wish to take account of the state of the new society, but to disregard the profound modifications introduced into the customs by Christianity, based on the genius of the western peoples; this is to efface several centuries of slow but persistent labor, produced in the midst of society; work that has developed the most active and vivacious elements of modern civilization. No one admires antiquity more than we do, and on one is more disposed to recognize the superiority of the best epochs of the art of the Greeks and Romans over modern arts; but we were born in the 19<sup>th</sup> century, and we cannot prevent that between antiquity and us has been much labor; ideas, needs, means foreign to those of antiquity. It is necessary for us to take account well of the new elements, of the tendencies of a new society. We may regret the social organization of antiquity, scrupulously study it, have recourse to it; but do not forget that we neither live under Pericles nor under Augustus; that we have no slaves; that three fourths of Europe are no longer plunged in ignorance and barbarism to the great advantage of the other fourth; that society is not divided into two unequal portions, the larger absolutely subject to the other; that needs have infinitely extended; that the machinery is complicated; that industry continually analyzes all means placed at the disposal of man and transforms them; that traditions and formulas are re-

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...and not transforms them. Last traditions and formulas are re-

replaced by reasoning, and that finally for art to endure it must know the atmosphere in which it develops. Now the construction of edifices in the middle ages entered into that new path. We may bemoan this, if we wish; but the fact will not exist, and we can only make yesterday the eve of today. It seems to us that what is best is to seek in the work of yesterday what is useful for us today, and to recognize whether that labor has not prepared for the labor of today. That is more reasonable than to disdain it.

It has been frequently claimed that the middle ages were an exceptional epoch, neither connected with what preceded nor followed it, foreign to the genius of our country and to modern civilization. That may perhaps be sustained from the point of view of politics, although such a fact may be very strange in the history of the world, all linked together; but the spirit of party being mixed with it, it is no paradox finding approvers. In architecture and especially in construction, party spirit has no hold, and we do not see why the principles of civil liberty, why the modern laws under which we have the happiness to be born are attacked, when it is demonstrated, that the constructors in the 12 th century knew how to build, that those of the 13 th century were very ingenious and free in the use of the means, that they sought to fulfil the progress imposed on them, by the simplest and least expensive means, that they reasoned correctly and knew the laws of statics and of the equilibrium of forces. A custom may be odious and oppressive; abbots and feudal lords were spendthrifts, if you prefer, exercised an insupportable despotism, and the monasteries and castles inhabited by them might still be constructed with wisdom, economy and great liberty in the use of the means. A structure is not fanatical, oppressive or tyrannical; these are not applied to a combination of stones, wood or iron. A structure is good or bad, judicious or without reason. If we have nothing to take from the feudal code, that is not saying that we can take nothing from the structures of that time. A court condemns unfortunate Jews or sorcerers to be burned alive; but the hall in which sits that court might be a very good structure, and as well built as that in which our magistrates apply wise laws in an enlightened spirit. A man of letters, a historian, says in speaking of a feudal cas-

regarded by themselves, and that finally for the sake of the  
 must know the atmosphere in which it develops. The one thing  
 position of affairs in the middle ages showed that the  
 until he may become blind, it is not; but the fact will be  
 in a crisis, and he can only make yesterday the day of today.  
 it seems to me that what is done in the world is not of the  
 today, and is useful for us today, and so tomorrow we shall  
 that labor has not prepared for the labor of today. That is  
 more reasonable than to disain it.

It has been frequently stated that the middle ages were an  
 exceptional world, rather connected with the present world.  
 followed it, foreign to the history of the country and to the  
 even civilisation. That was because we separated from the his-  
 of view of history, which was a fact was to very much  
 was in the history of the world, all things considered; and the  
 spirit of party being mixed with it, it is so narrow and  
 everywhere. In architecture and essentially in construction, it  
 party spirit has no hold, and we do not see any the original-  
 of civil liberty, why the subject have been which we have  
 the masses to be born are attacked, when it is demonstrated,  
 that the corporations in the 13th century knew how to build,  
 last stages of the 13th century were very important and even  
 in the case of the women, that they were so full of the pro-  
 have passed on them, by the physical and social progress and  
 and, that they passed through and were the last of the  
 on and of the civilization of France. A woman may be a  
 and progressive; and the last of the world was a woman. It  
 not only, everything is connected with the world, and the  
 and culture; and the world is the world of the world.  
 with the world, society and great things in the case of a  
 the world. A struggle is the struggle, a struggle of the  
 world; these are not applied to a condition of women, and  
 of the world. A struggle is good or bad, whether it is with the  
 world. It is not only in the world, but in the world of the  
 is not only in the world, but in the world of the world.  
 that time. A court of justice is a court of justice, and  
 be turned into a court of justice, and the world is the world  
 be a very good example, and as well as that in the  
 our civilization and the world is in our civilization, and  
 and of history, a historian, says in speaking of a feudal cas-

castle; "That resort of brigandage, that residence of petty despots tyrannizing over their vassals, at war with their neighbors." At once everyone raises a hue and cry about the lord of the castle. How are the edifices accomplices of those who caused their erection, particularly if those structures were erected by just those, who were victims of the abuse of power by their inhabitants? Did not the Greeks in many cases exhibit the most odious fanaticism? Does that prevent us from admiring the Parthenon or the temple of Theseus?

We believe it time to no longer allow ourselves to be dazzled, we architects, by the discourses of those strangers to the practice of our art, who judge works that they cannot understand, and <sup>of</sup> which they neither know the construction nor the true and useful sense, and who are moved by their passions or personal tastes, by restricted studies of a narrow party spirit, cast anathemas on artists, whose efforts, science and practical experience are still of great assistance to us today. It is of slight importance that those feudal lords were tyrants, that the clergy of the middle ages was corrupt, ambitious and fanatical, if the men who built their habitations were ingenious, if they loved their art and practised it with skill and care. It matters little to us that a dungeon shut in the living for years, if the stones of their prison were skilfully cut and present an impassable obstacle; little to us that a grille enclosed a chamber of torture, if the grille were well combined and the iron well forged. Confusion between the institutions and the products of the arts must not exist for us, who seek our own wherever we think of finding it. Let us not be duped at our own cost by restricted doctrines; let us blame the customs of past time, if they seem bad to us; but let us not proscribe the arts, before knowing whether we can derive any advantage from their study. Let us leave to enlightened amateurs the care of discussing the preeminence of Greek over Roman architecture, and of that over the architecture of the middle ages; leave them to treat these insoluble questions; if we have nothing better to do, let us listen to discussions on our art without knowing how to draw a panel, to cut and set a stone; it is not permitted to profess medicine or even pharmacy without being a physician or an apothecary; but for architecture, that is a different affair!

unhappy: "That sense of discipline, that restraint of energy  
 despotic government over their families, at war with their  
 neighbors." At once everyone raises a hue and cry about the  
 lord of the manor. Now are the editors acquainted of those  
 who caused their execution, particularly if those structures  
 were erected by John Fane, who were victims of the same of  
 power by their immobility? Did not the Crown in every case  
 exhibit the most obvious fanaticism? John Fane, indeed, is too  
 admitting the fact that the people of England?

It is believed it does to no longer allow ourselves to be led  
 into, we are told, by the influence of large elements of  
 the strength of our art, who judge works that they cannot un-  
 derstand, and which they neither know the construction nor the  
 the true and useful sense, and who are moved by their passion-  
 ate or partial tastes, by restricted studies in a narrow sphere  
 of art, and whose efforts, whose efforts, are limited to a  
 conventional standard and still in their position in the world.  
 It is of slight importance that those feudal lords were types  
 now, that the class of the middle class was without, and that  
 not feudal, it is the same and still their position was in-  
 dependent, if they loved their art and occupied it with skill  
 and care. It matters little to us that a nobleman sat in the  
 living room, if the spirit of their art was still  
 in our art, and presents an insupportable contrast: little to us that  
 a nobleman sat in a chamber of luxury, if the style was  
 well contained and the iron well looked. Connection between the  
 institutions and the products of the art must not exist for  
 us, and each art must be what it is, and of course it is the  
 not to be led by our own sense of restricted knowledge; but to  
 know the nature of each thing, it is not to be led by our  
 but to be responsible for the art, before we have reached the  
 further any advantage from their work. Let us leave it to  
 the hands of the art of the day, the prominence of the  
 Greek over Roman architecture, and to the art of the  
 end of the middle ages; let us leave it to the hands of the  
 imagination, if we have nothing better to do, let us listen to  
 the imagination on our art without knowing how to draw a pencil, to  
 let and not a word; let us not pretend to produce anything  
 or even to be without being a student of an academy;  
 and for architecture, that is a different matter!

To render an account of the first efforts of the constructors of the middle ages, it is first necessary to know the elements at their disposal, and the practical means then in use. The Romans, masters of the world, having established a regular and uniform government in the midst of so many allied or conquered peoples, hand in their hand resources absolutely wanting in the provinces of Gaul divided into little states, innumerable fractions, because of the establishment of the feudal system. When the Romans desired to cover a province with monuments of public utility, could place at a point at a given moment not only an army of soldiers accustomed to labor, but could levy the inhabitants (for the system of forced levies was practised on a vast scale by the Romans), and to obtain prodigious results by the aid of that multitude of laborers. To build rapidly and well, they had adopted methods according perfectly with that social state. If the constructors of the middle ages had desired to employ those methods, where would they have found those armies of laborers? How transport into a province without stone, for example, the materials needed for construction, when the ancient Roman roads were broken, how obtain the money to purchase these materials, beasts of burden, when the provinces were almost at war with each other, when each abbot and each lord considered himself as an absolute sovereign, the more jealous of his power, the smaller the country over which it extended? How organize regular levies of men where several authorities disputed the supremacy, and where laborers were scarcely in sufficient number to cultivate the soil, where war was the normal condition? How to accumulate the enormous mass of provisions required for the smallest Roman structure? How to feed these laborers at the same point? The religious orders could first undertake important structures, 1, because they gathered at a single point a sufficient number of laborers combined by a single thought, subject to discipline, free from military service, owners of areas on which they lived, 2, because they gathered possessions, that rapidly increased under a regular administration, that they formed permanent relations with neighboring establishments, they cleared and rendered healthy uncultivated lands, laid out roads, acquired the richest quarries and the best forests, built shops, offered the peasants protection com-

To render an account of the first efforts of the government  
 of the United States, it is first necessary to know the al-  
 ready existing conditions, and the practical results of the  
 the various, nature of the world, having established a result-  
 ing and entire agreement in the order of its early allied  
 countries, and in their early relations absolutely  
 existing in the various of the United States, and in the  
 international relations, because of the importance of the  
 local system, then the system desired to govern a province  
 with movements of public affairs, could have no other  
 a given moment not only an army of soldiers associated to the  
 war, but could have the government (the war system of the  
 law) was practiced on a vast scale by the Romans, and to  
 create a political system by the aid of the military of the  
 state, to which could not will, then the whole world  
 according perfectly with that social state. If the constant  
 one of the middle ages had desired to enter those methods, w-  
 here would they have found those series of laborers? How ar-  
 rangements into a province without cause, for example, the war-  
 like system for construction, when the system of the  
 were broken, the whole of the system to be broken down, and  
 series of battles, when the principles were placed at war with  
 each other, when each state and each town maintained itself  
 as an absolute sovereignty, the whole system of the world, and  
 smaller the country over which it exercised its power, and  
 the division of the whole several independent states, the re-  
 sult, and where laborers with masters in different con-  
 ditions, and on different the whole, which was the social condition  
 for to maintain the whole of the system remained  
 for the whole of the system, and the whole of the system  
 at the same point? The religious orders could first undertake  
 independent enterprises, 1, because they gathered at a single  
 point a sufficient number of laborers combined by a single  
 method, subject as discipline, from their religious  
 orders of monks or nuns, they lived, 2, because they gathered  
 themselves, that rapidly increased under a single religious  
 system, that they formed permanent relations with religious  
 establishments, they gathered and gathered religious establishments  
 lands, and the whole, and the whole of the system remained  
 that system, that system, that system, that system, that system,

comparatively secure, and thus rapidly peopled their lands, to the detriment of those of the lay nobles, 3, because by their privileges and the relative stability of their institutions, they could form within their monasteries schools of artisans, subject to a regular apprenticeship, clothed, fed and supported, working under the common direction, preserving the traditions and recording improvements, 4, because they alone then extended afar their influence by founding establishments connected to the mother abbey, so that they must profit by all partial efforts made in provinces differing greatly in climate, customs and habits. By the activity of the religious orders the art of construction must rise from barbarism in the 11 th century. The order of Cluny as the most important (Art. Architecture Monastique), most powerful and most enlightened, was the first to have a school of constructors, whose new principles must produce in the 12 th century monuments freed from the last Roman traditions. What are those principles? How were they developed? That is what we are to examine.

PRINCIPLES. For new principles to develop in anything, it is necessary for a new condition and new needs to appear. When the order of S. Benédicte was reformed in the 11 th century, the tendencies of the reformers say nothing less than to change the entire society, that was scarcely founded and already was falling into decay. Those reformers as skilful men commenced by abandoning the mouldy traditions of antique society; they started with nothing and no longer desired habitations both luxurious and barbarous, which until then had served as refuge for monks corrupted in the preceding centuries. They built themselves huts of wood, lived in the midst of fields, taking life as men could when left to their industry alone in a desert. These first steps had a persistent influence, when even the increasing wealth of the monasteries, their importance in the midst of society soon brought them to exchange their cabins for durable habitations built with luxury. To rigorously satisfy needs is always the primary law observed, not only in the entirety of the structures, but in the details of construction; never to sacrifice stability to a vain appearance of wealth is the second. Yet stone and wood are always stone and wood, and if one can use these materials in quantity more or less great in a structure, their function

comparatively simple, and less rapidly changed than  
 as the demand of those of the lay nobles, & because by a  
 their activities and the relative stability of their insti-  
 tutions, they could turn within their monastic schools up  
 religious, subject to a regular curriculum, directed, for  
 and supported, working under the common direction, preserving  
 the traditions and ecclesiastical government; & because they a-  
 lways then returned after their long absence to the same insti-  
 tutions connected to the same order, so that they were dis-  
 tinct by all mental efforts made in previous religious study-  
 ing in cloister, courses and habits by the activity of the re-  
 ligious orders and the of construction with the first insti-  
 tution in the 11th century. The order of Cistercians was the first in-  
 stitute (the Benedictine monasteries), most powerful and most  
 influential, was the first to have a school of construction,  
 whose new principles were produced in the 12th century monas-  
 ters traced from the last Roman civilization. That was those or-  
 ders, but were they definitely that in which we are to remain.  
 THIRTEENTH. For new principles in building in architecture, it is  
 necessary for a new institution and the desire to construct. Then  
 the order of St. Benedict was returned in the 11th century, &  
 the perfection of the religious art, which had been in con-  
 tinuous growth, that was seriously founded and already  
 was falling into decay. These reforms or efforts and conser-  
 vation of antiquities the early traditions of religious society  
 they started with nothing and no longer needed institutions  
 good luxuries and pleasures, which were then and served as  
 escape for monks untroubled in the monastic order. They  
 could themselves have of work, lived in the midst of fields,  
 taking life as men would have left in their former state  
 in a hermit. These first steps had a permanent influence,  
 and even the increasing result of the construction, itself  
 importance in the midst of society soon brought them to ex-  
 pose their claims for durable institutions built with luxury.  
 To rigorously religious needs in which the clergy had passed-  
 ed, and only in the activity of the structure, but in the  
 isolation of construction; never in connection with the  
 with construction of walls in the second. Yet walls and thus  
 are always more and more, and if one can use them as barriers  
 in quantity more or less strong in a structure, their function

is the same among all peoples and in all times. However rich and powerful the monks, they could not hope to build as the Romans had done. Thus they endeavored to erect structures both substantial and durable (for they indeed counted on building for the future) with economy. To employ the most ordinary Roman method, i.e., to compose their structures of massive concrete faced with surfaces of bricks or rubble, was to set at work more laborers than they had at command. To construct with enormous blocks of stone, carefully dressed and set, would have required impossible transportation for lack of solid roads, and a considerable number of skilful workmen, beasts of burden, expensive machines established with difficulty. Thus they took a middle course. They erected principal points of support by employing cut stone for the surfaces as a facing, filling the interior with concrete; for the connecting walls they adopted masonry of small stones rough dressed on the surfaces or square stone slabs, likewise enclosing concrete of pebbles and mortar.

Our Fig. 2 gives an idea of this kind of construction. To tie together the different parts of the structure and tie the walls lengthwise, long timbers were buried in the masonry at different heights, beneath the window sills and over the cornices, as we have shown at A. (Art. Chainage). In these structures, stone is economized as much as possible; no block is hollowed and all are set on edge; this is only a facing though executed with the greatest care, not only are the surfaces dressed, but also the beds and joints, and these stones are set dry without mortar like Roman masonry.

This kind of construction is apparent in the great monastic structures of Cluny, Vezelay, Charite-sur-Loire (11 th and 12 th centuries). The materials employed by the monks are those procured in the vicinity, in quarries which they owned. And it must be recognized, that they were used in accordance with their qualities and defects. If the materials present defects, if the stone splits easily and no other could be procured except at considerable expense, they took care to place it under the least disadvantageous conditions, and to protect these materials from the effects of dampness and of frost, they sought to relieve them from atmospheric action by raising them from the soil externally by courses of stone purchased

in the same manner all together and in all places. However this  
and provided the work, they could not have been as the  
shown and done. This fact is supported by the fact that the  
substantial and durable (the fact is that the work is done on building  
for the future) with economy. In doing the work the only difficulty  
was not, i.e., to obtain their assistance of various kinds  
these facts with reference to the work in hand, and as well as  
work more laborers than they had at command. To construct with  
various kinds of work, carefully treated and set, would a  
have required impossible transportation for that of still re-  
sult, and a considerable number of skilled workers, besides of  
hundred, extremely accurate and finished work. This  
very easy a little more. They wanted technical means of  
support by amplification and alone for the purpose of a building  
filling the interior with concrete; for the connecting walls  
they erected masonry of small stones rough dressed on the sur-  
face or square stone slabs, likewise enclosing concrete of a  
medium and better.

Our Fig. 2 gives an idea of this kind of construction. To  
the exterior the different parts of the structure are the  
walls themselves, load timbers were buried in the masonry at  
different heights, beneath the window sills and over the cor-  
nices, as we have shown at A. (Art. Concrete). In these struc-  
tures, which is constructed as with an exterior wall, the  
colored and all the rest of the work is only a thin layer  
erected with the greatest care, not only for the purpose of  
dressed, but also the beds and joints, and these stones are  
not any without mortar like these masonry.

This kind of construction is important in the great quantity  
associated of stone, timber, concrete and masonry (it is an  
in the quantities). The materials employed by the masons are in-  
one procured in the vicinity, in quantities which they used.  
and it must be remembered, that they were used in woodlands  
with their own hands and labor. If the material is  
defects, if the stone is better and no other could be  
used except at considerable expense, they took care to place  
it under the least disadvantageous conditions, and to require  
these materials from the effects of the work and of the  
they sought to relieve them from unnecessary action by raising  
and from the soil externally in order to give the

in the most distant quarries.

In the works of men counting only on their own resources and their own strength, there is always a certain amount of intelligence and of energy of great value in the eyes of those knowing how to observe, however imperfect and rude are these works otherwise, which one does not find in the works produced by very civilized men, but to which industry supplies numerous elements, and that have to make no effort to satisfy all their needs. These primitive seekers then frequently become masters, and their efforts a precious instruction, for it evidently requires more intelligence to make something when all resources are lacking, than when they are within the reach of the most mediocre minds.

Roman structures, because of the absolute stability of their points of support and the perfect cohesion of all upper parts (the result obtained by means of immense resources, as we have stated), present immovable and passive masses, as if they were monuments out in a solid block of tufa. Romanesque constructors not being able to dispose of such powerful means, soon recognized that their structures did not offer a concrete entirety, tied together and a perfectly stable combination; that the piers being composed of facings of stone enclosing a concrete of frequently poor mortar, and that the walls were not bonded in their entire height, suffered the effects of unequal settlements, that caused cracks in the structure, and consequently serious accidents. It was then necessary to seek means suited to neutralize these effects. Romanesque constructors from the 11th century desired by motives then developed (Art. Architecture) to vault most of their great edifices: they had inherited Roman vaults, but they were not able to maintain them by the powerful means, that the Romans had been able to adopt. It was then again necessary, that their intelligence should replace that lack of power. The Roman vault could only maintain itself on condition of having absolutely stable points of support, for that vault, whether tunnel, cross or hemispherical, forms a homogeneous covering without elasticity, that breaks into pieces if any cracks occur in its intrados. Desiring to build vaults in imitation of the Romans, and not being able to give them absolutely stable points of support, it was necessary for the Romanesque constr-



constructors to find some method for maintaining them in accordance with the instability of the points of support destined to bear and to abut them. This task was not easily solved; so experiments, attempts and trials were numerous; but still from the origin of these attempts is seen the birth of the new system of construction, and this system is based on the principle of elasticity, replacing the principle of absolute stability adopted by the Romans. With rare exceptions the Roman vaults are made of concrete; if reinforced by brick arches, these arches are embedded in the thickness of the concrete itself, and unite with it. The Romanesque constructors, instead of building the vault of concrete, constructed it of rough rubble embedded in mortar, but set as voussoirs, or as dressed rubble composing masonry of small stones; already these vaults, if a vertical movement occurred in the points of support, presented a certain elasticity, because of the combination of the voussoirs, not breaking like a homogeneous covering, and following the movement of the piers. But this first modification did not entirely reassure the Romanesque constructors; they established under these vaults at certain distances at the most resistant points of support, transverse arches of cut stone turned beneath the intrados of the vaults. Those transverse arches, a sort of permanent elastic centres, like every arch composed of a certain number of voussoirs, followed the movement of the piers, yielded to their settlement and their divergence, thus maintaining like a wooden centering the shells of masonry built above them.

Romanesque constructors had taken from the Romans the cross vault on a square plan produced by the intersection of two half cylinders of equal diameters. But when they wished to erect vaults on piers placed at the angles of rectangles, the cross vault could not be applied; in that case they adopted the tunnel or continuous half cylindrical vault without intersections, and at the piers they strengthened these tunnel vaults by transverse arches of cut stone, on which they relied to avoid the bad effects of a longitudinal rupture in these tunnel vaults, because of the movement of the piers. Again, and we insist on the point, this was a permanent centering. Still the obstacles and the difficulties seemed to appear as the constructors believed they had found the solution of the

constructed in that form called for maintaining them in shape  
 areas with the instability of the points of support designed  
 to bear and in that form. This fact was not easily solved; an  
 experiment, attempts and trials were numerous; but still from  
 the origin of these attempts in view of the fact of the  
 use of construction, and the system is based on the principle  
 of elasticity, containing the principle of elastic stability  
 adopted by the French, with rare exceptions the French system  
 the rule of construction is maintained by which arches, those  
 points are excluded in the system of the concrete vault  
 and also with the construction of construction, instead of  
 building the vault of concrete, constructed it of rough rubble  
 is essential in contact, not as previously, or as directed by  
 rapid mechanical means of small amount; already these vaults  
 if a vertical system occurred in the state of rupture, the  
 reaction a certain elasticity, because of the construction of the  
 the vaults, and pressure like a homogeneous mass, and  
 following the movement of the pier. But this first modification  
 did not entirely remove the French construction;  
 they substituted other small vaults at certain points of the  
 the most resistant points of rupture, however, and in  
 not more toward the interior of the vault. These  
 structural arches, a sort of permanent elastic member, like  
 every other component of a certain number of vaults, follow  
 at the movement of the pier, yielding in their movement and  
 their distance, thus maintaining them a certain contact with  
 the shells of masonry built above them.  
 The French construction has taken from the vault the three  
 vault on a square pier produced by the intersection of two in  
 half vaults of equal diameter. But now they turned to a  
 three vaults on piers placed at the angles of rectangles, the  
 three vault could not be applied; in that case they adopted  
 the vault of hexagons; half cylindrical vaults placed together  
 vaults, and at the piers they strengthened them with the  
 also by increasing areas of contact, on which they relied  
 to avoid the bad effects of a localised rupture in these  
 barrel vaults, because of the movement of the pier. And, a  
 and we looked on the point, this was a permanent construction.  
 All the principles and the difficulties raised in regard to  
 the construction called for had found the solution of the

problem. The effects of the thrusts of vaults so perfectly known to the Romans were almost ignored by the Romanesque constructors. The first among them who had the idea of turning a round tunnel vault on two parallel walls certainly believed, that he had forever avoided the inconveniences attached to visible carpentry, and combined a construction both solid and durable, with a monumental appearance. His illusion must have been of short duration, for after removing the centres and lagging, the walls were overturned outwards, the vault falling between them. It was then necessary to find means suitable for preventing such disasters. They first strengthened the walls by external buttresses, by piers projecting inside, then at these buttresses and piers they turned transverse arches under the tunnel vaults. Burying longitudinal timbers in the thickness of the wall between the piers at the springing of the tunnel vaults, they believed thus to arrest their thrust between these piers. This was always only a palliative; if so some edifices thus vaulted resisted the thrust of the tunnel vaults, a great number fell some time after their construction.

But it is necessary for our readers to have an accurate idea of this last kind of construction. We give (3) its entirety and details. At A are the internal piers supporting the transverse arches E, at B being the longitudinal timbers retaining the tunnel vault at its springing. In order to carry the thrust of the transverse arches as low as possible, the constructors gave a strong projection to the capitals G. If vaults so conceived were turned on piers sufficiently solidly built with well tied or very heavy materials, if the walls were thick and solid from bottom to top, if the buttresses had a sufficient projection, and the transverse arches and consequently the piers were not too widely spaced, these tunnel vaults, reinforced by lower arches, could be maintained. But if as occurred in naves bordered by side aisles, the walls rested on the archivolts of isolated piers, if these isolated piers, that were always tied to make them as thin as possible, to not obstruct passage and obstruct the view, did not present a sufficient bearing to receive the external buttresses projecting above the vaults of the side aisles, then the upper tunnel vault in spite of, or with its transverse arches gradually pushed the piers and walls outward, and the entire structure fell.

However, the effects of the change of vaults so perfectly  
 known at the Romans were almost ignored by the Renaissance con-  
 structors. The first among them who had the idea of turning a  
 round tunnel vault up and parallel walls certainly failed.  
 It is not to be forgotten that the Renaissance architects in a  
 visible manner, and certainly a conspicuous manner, had  
 done up their vaults, for after receiving the vaults and in-  
 tending, the walls were overturned outwards, the vault fall-  
 ing between them. It was then necessary to find means suitable  
 for traversing such structures. The first attempted was  
 walls by external buttresses, or other projecting loads, and  
 at these buttresses and other loads, however, when  
 under the round vaults, turning outwards, the  
 thickness of the wall between the pier at the beginning of a  
 the tunnel vaults, they believed that to appear their vaults  
 between these piers. This was always only a delusion; if an  
 even without any vaults, the vaults of the tunnel  
 vaults, a great error fell into their hands.  
 But it is necessary for our readers to have an accurate idea  
 of this last kind of construction. We give (2) its entire  
 and details. At A are the internal piers supporting the trans-  
 verse arches B, at C being the external (transverse) buttresses  
 the tunnel vault at its beginning. In order to carry the trans-  
 verse arches across as low as possible, the transverse  
 have a square projection at the vaults C, the vaults in con-  
 nected with the piers externally with the vaults  
 wall that at very heavy vaults, if the walls were built a  
 and solid from bottom to top, if the buttresses had a solid  
 base projection, and the transverse arches and buttresses  
 the piers were not too widely spaced, these tunnel vaults,  
 reinforced by lower vaults, could be retained. But it is  
 occurred in cases where the walls, the walls being  
 on the outside of isolated vaults, of some limited extent,  
 that were always tried to make them as thin as possible, to not  
 obstruct passage and obstruct the view, did not present a self-  
 sufficient vaulting as vaults and external buttresses projecting  
 above the vaults of the side aisles, then the vaults were  
 left in place of, or with the transverse arches externally vault-  
 ed the aisle and vaults outward, and the vaults outward vaults.

Already about the end of the 11 th century, many of the churches so vaulted and built for a half century fell in ruin, and it was necessary to rebuild them. These accidents were an instruction to builders; this gave them the opportunity for observing certain phenomena of statics, of which they had not the least idea; it caused them to recognize that the wooden timbers embedded in the masonry and deprived of air quickly became rotten, and that the vacancy they left only hastened the destruction of the edifices; that the walls having commenced to overturn, the thrust of the vaults directly increased their moment; that finally if the tunnel vaults were placed over naves with side aisles, the disorder occasioned by the high vaults were such, that it was impossible to maintain the piers and walls in a vertical plane.

Yet the moment had not then come, when the constructors undertook to accurately solve the problem of the stability of vaults placed on parallel walls; they must still make attempts to avoid the effects of the thrust on the vertical walls. Romanesque constructors knew that cross vaults presented this advantage of exerting pressures and thrusts only on the four points of support receiving their springings. Recognizing that tunnel vaults exerted a continuous thrust on the tops of the walls, they sought to replace and suppress them, even in naves composed of bays oblong in plan, by cross vaults, so as to transfer their entire weight and thrust to the piers, which they hoped to make stable. But as we have stated above, the Roman cross vault could be built only on the square plan; it was then necessary to find a new construction of cross vaults suited for oblong vaults. Geometrically, these vaults could not be drawn, and it was only by experiment that men succeeded in constructing them.

Already during the 11 th century, the constructors had composed vaults that are allied to both the dome and the cross vault, in that these vaults, instead of being generated by two half cylinders intersecting at right angles, are formed by four round arches connecting the four piers and two diagonal arches, which are themselves round, consequently having greater radii than these of the four first. When one knows the means employed to construct the cross vault, it is easily understood what had been the motive of that modification of



the Roman cross vault. To build the vault are necessary wooden centres on which are laid planks. Now to make a Roman cross vault, there must be made four semicircular centres and two diagonal centres, whose curve is given by the intersection of the half cylinders; the curve of these diagonal centres is not a semicircle, but an ellipse obtained by ordinates, as indicated in Fig. 4. Let  $AB$  be the diameters of the cylinders and  $BC$  the horizontal line of the plan over which they intersect. the two cylinders  $AB$ ,  $AC$ . Working on a quarter, and dividing the revolved semicircle into a certain number of equal parts  $DE$ ,  $EF$ ,  $FG$ ,  $GB$ , perpendiculars are dropped from these dividing points  $D, E, F, G$  on the diameter  $AB$ , prolonging them to intersect the diagonal  $BC$ . Thus one obtains on that diagonal the dividing points  $d, e, f, g$ ; from these points  $e$  erecting perpendiculars to the diagonal  $BC$ , and taking on these perpendiculars lengths  $dd' = D'A$ ,  $ee' = E'E$ , etc., there are fixed the points  $d', e', f', g'$ , through which is traced the curve of intersection of the two half cylinders. This curve having a rise  $dd' = \text{radius } D'D$ , and a diameter  $BC$  greater than the diameter  $AB$ , cannot be a semicircle. Although very simple, this geometrical drawing appeared too complex to the Romanesque constructors. Having then traced a semicircle on the diameter  $AB$  for making the wooden centres for the four generating arches of the vault, they traced a second semicircle on the diameter  $BC$  for making the two diagonal centres. Thus the crowns of the intersection of these two diagonal centres found themselves at a level higher than the crowns  $D$  of the generating arches, and the vault instead of being the result of the intersection of two half cylinders, was composed of nameless surfaces, but approaching the dome. This elementary demonstration is necessary, for it is the key of the entire system of vaults of the middle ages. This first result, of ignorance rather than calculation, however was one of the most fruitful principles in the history of construction. Further it indicates something other than gross ignorance, if denotes a certain reflective liberty in the use of the means of building, whose importance is considerable; and indeed once freed from Roman traditions, the constructors in the middle ages were more and more consistent with their principles; they soon comprehended their entire extent, and frankly aban-



abandoned themselves to them; however, let us follow them step by step. Once the principle of the Roman cross vault was thus modified, it was necessary to apply these vaults to rectangular plans, for the constructors recognized the danger of wide tunnel vaults.

Then (5) let  $A B C D$  be the rectangle of a bay of the nave in plan, that must be covered by a cross vault. Let  $A E B$  be the semicircular intrados of the transverse arches revolved, and  $A F C$  be the semicircular intrados of the side arches also revolved. It is clear that the radius  $H F$  will be shorter than the radius  $G E$ , also the crown  $E$  is higher than the crown  $F$ . If we trace a semicircle on the diagonal  $A D$  as being the curve on which must intersect the vaults generated by the semicircles  $A E B$ ,  $A F C$ , it will result that the angles  $A I$ ,  $B I$ ,  $D I$  and  $C I$  will be concave instead of convex for their entire length, on the contrary for about two thirds of their length, and principally in approaching the crown  $I$ .

Indeed, let (6) be the cross section of the vault on  $H O$ . Let  $H(F')$  be the section of the side arch,  $H'I'O$  the vertical projection of the diagonal  $A D$  or  $B C$ . The straight line drawn from the crown  $F$  to the crown  $I'$  leaves a segment of the circle  $K L I'$  above that line; from which it results that this portion of the vault must be convex to the intrados instead of being concave, and that consequently it could not be constructed. Then placing the side and transverse arches on the diagonal arches and laying the planks to close the triangles of the masonry vaults, the constructors covered this centering by a thick mass of earth following the curve  $F'I'F''$ , i.e., given by the summits of the diagonal and side arches; then the diagonal groins again became convex, on this mass were set courses of rubble parallel to the section  $F'I'$  to close the vault.

The result of these experiments was that the cross vaults were no longer intersections of cylinders or cones, but of ellipsoids. The first difficulty being overcome, rapid improvements could not fail to develop. But at first, how and by what mechanical procedures were these vaults constructed? The Roman cross vault was constructed by bays and had no transverse arches; it rested on piers or projecting columns, as represented in Fig. 7, i.e. (see the horizontal projection  $A$



of one of those vaults), the diagonals B C, D E, produced by the intersection of two half cylinders of equal diameters and forming convex groins, rested on the projecting angles of the piers. But the Romanesque architects having first strengthened the great tunnel vaults by transverse arches, as shown by our Fig. 3, and replacing those semicylindrical vaults by oblong cross vaults, retained the transverse arches; they could not do otherwise, since the diagonals of these vaults were semicircles, and their curves rose above the crowns of the arches, whose diameters were given by the distance between the piers.

To make ourselves understood, let (8) be the longitudinal section of a Roman cross vault composed of bays; the line A B is horizontal; it is the section of a longitudinal cylinder. Let (8 bis) be the longitudinal section of a Romanesque cross vault on an oblong plan, the line A B is a series of curves, or at least of broken lines joining the points C D, summits of the transverse arches at the points of intersection of the diagonal semicircles. It was necessary to retain beneath the points C D projecting arches, transverse arches, which were merely permanent centres, as we have already stated. Henceforth the diagonal groins must start from a point beyond the projection of the piers or columns, these being only destined to support the transverse arches, i.e., (9), that the groins must start from points F instead of from points G, and that the springings of the transverse arches rest on the bearings F, H, G, I. When it was then necessary to close the vaults, the constructors placed the lagging supporting the masses or form of earth on the extradoses of these transverse arches, and on <sup>the</sup> two diagonal arches of carpentry.

In the structures erected by all the building peoples, logical deductions succeed with fatal rigor. A step made in advance can never be the last; one must always progress; from the moment that a principle is the result of reasoning, one soon becomes its slave. Such is the spirit of the western peoples; it appears when the society of the middle ages commences to feel and to organize itself; it cannot stop, for the first that establishes a principle by reasoning cannot say to reason; "thou shalt go no farther." Constructors in the shadow of the cloisters recognized this principle from the 11 th cen-



century. A century later, they were no longer the masters. Bishops, monks, nobles, citizens, had they desired it, could not have prevented Romanesque architecture from producing the architecture called Gothic; the latter was the fated consequence of the former. Those desiring to see in Gothic architecture (entirely lay) anything but the emancipation of the people of artists and artisans taught to reason, who reasoned better than their masters, and in spite of themselves carried them very far from the aim, that all at first desired to attain, with the forces placed in their hands; those believing Gothic architecture to be an exception, an oddity of the human mind, certainly have not studied the principle, which is only the rigorously followed application of the system introduced by Romanesque construction. It will be easy to demonstrate this. Let us proceed.

We already see at the end of the 11 th century the principle of the Roman cross vault set aside.<sup>1</sup> Transverse arches are definitely accepted as a living, elastic and free force, a skeleton on which rests the vault proper. If the constructors admitted that these permanent centres were useful transversely, they must similarly admit their utility longitudinally. No longer regarding the vaults as a homogeneous concrete covering, but as a series of compartments with curved and free surfaces resting on flexible arches; the rigidity of the lateral walls contrasted with the new system; it was necessary for the compartments to be free in every sense, or otherwise breaks and cracks would be the more dangerous, because these vaults were supported on flexible arches in one direction and on rigid walls in the other. They turned side arches on the walls lengthwise between the piers. These side arches were merely half transverse arches partly embedded in the wall, but not dependant on its construction. By this means the vaults rested only on the piers, and the walls became mere enclosures, that if necessary could be built afterwards or omitted. A bearing was required for these side arches, a special point of support; Romanesque constructors then added for this purpose a new member to their piers, and the cross vault began in the reentrant angle formed by the impost of the transverse arch and the side arch, as indicated in Fig. 10. A is the transverse arch, B the side arch, C the groin of the vault; the plan



of the pier is at D. But if the pier was isolated, if the nave was accompanied by side aisles, it assumed in plan Fig. 10 bis. A is the transverse arch of the great vault, B the archivolts supporting the wall. Above these archivolts, this wall recedes at F so as to permit the pilasters G to bear the upper side arches. C is the transverse arch of the side aisle; D are the groins of this side aisle, and H those of the high vaults. T The vaults to the side aisles are turned on the transverse arches C, the extradoses of the archivolts B and on a side arch partly embedded in the wall of the side aisle, and supporting like the upper side arches of Fig. 10. Thus already the members of the vaults give the horizontal section of the piers, their form being derived from these members. Yet these vaults were abutted insufficiently, and movements made themselves felt in the piers; hence the principal ribs of the vaults, the transverse arches were deformed. Not knowing how to resist the thrusts, constructors first occupied themselves with rendering this effect less injurious. They had observed the greater the area of the section of an arch between the intrados and extrados, the more the movements produced in the arch occasioned disorder. They were not the first to recognize this law. The Romans before them, when they had to turn great arches, took care to form them of several rows of concentric voussoirs, independent of each other, as indicated by Fig. 11 at A. Arches constructed in this manner formed as many hoops acting separately, and retaining a much greater elasticity, consequently with more resistance than an arch of the same section constructed according to the method indicated at B.

Note 1.p.21. In the nave of the church of Vezelay must be established the abandonment of the Roman system. There the cross vaults on oblong plans are already intersections of ellipsoids with projecting transverse and side arches.

Romanesque constructors according to this principle composed their transverse arches of two series of concentric voussoirs; that of the intrados assuming a section or portion of the radius longer than that of the extrados, and as the transverse arches were only permanent centres intended to receive the ends of the lagging on which the vault was built; they gave to a second series of voussoirs a projection beyond the first and suited to support the ends of the lagging. Fig. 12 expla-

of the pier is at D. But if the pier was isolated, it can have  
 was accompanied by side aisles, it assumed in plan the form of a  
 a transverse arch of the great vault, and the archivolts  
 supporting the wall. Above these archivolts, this wall receives  
 it so as to carry the piers 6 to bear the upper side  
 vault. C is the transverse arch of the side aisle; D and E  
 piers of this side aisle, and F those of the high vault. G  
 The vaults to the side aisles are turned on the transverse  
 arches, the extradoses of the archivolts 8 and on a side  
 wall vaulted in the wall on the side aisle, and  
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 at the piers, the archivolts first supported themselves with  
 resting this effect on the piers. Then the vaults were  
 turned the area of the section of an arch between the intra-  
 muros and extrados, the more the movements produced in the arch  
 produced disorder. They were not the first to recede from this  
 law. The human body first, then the vaults and the side arches  
 so, took note of four feet of height, and of a vaulted space  
 vaults, independent of each other, as indicated by Fig. 11 at  
 1. Another manifested in this manner formed as many houses  
 for separately, and retaining a much greater elasticity, com-  
 munity with the resistance than at first of the same vault  
 on concentrated vaulting as the vault indicated at 10.

Note 1. p. 21. In the nave of the church of Vézelay must be  
 established the relationship of the human system. There the  
 was vaults on vaults, there are always interventions of vaults  
 vaults with projecting transverse and side arches.

Transverse vaults manifest on their principal supports  
 their transverse arches of two series of vaulting supporting  
 that of the interior vaults a vault of section of the side  
 the lower than that of the extrados, and on the transverse  
 arches were only abundant counter resistance to receive the  
 vault of the lateral vault the vault and vault vault  
 to a vault series of vaults a vault series of vaults  
 not exist to support the vault of the lateral vault. 11 vaults

explains this method. At A is the row of voussoirs of the intrados, at B that of the voussoirs of the extrados with the two projections C intended to receive the ends of the lagging D on which the vaults are built. The side arches having a smaller diameter and being only subject to the effects of the thrusts, they are composed of a single row of voussoirs, as shown in Fig. 12 bis, with the projection necessary for placing the lagging. It is already evident that the Romanesque constructors left in evidence their material means of construction; that far from seeking to disguise them, composed their architecture with these means themselves. Are other proofs of this fact desired? The Romans terminated the tops of their columns by capitals; but the projection of the abacus of these capitals bore nothing; it was merely an ornament. Thus when the Romans placed the cross vault on the columns, as frequently occurred, for example in halls of baths, the impost of the vault was vertically over the side of the column (13). And then a singular thing, whose reason cannot be given, not only the shaft of the Roman column bore its capital, but the complete entablature of the order; so that indeed the entire portion between A and B served nothing, and that the strong projections B could have been utilized only for placing the carpentry centering intended for closing the vaults. It must be confessed that this was much luxury for an accessory purpose. When the Romanesque constructors placed an arch on an isolated or engaged column, the capital is only a corbelling destined to receive the impost of the arch, a projection serving as transition between the cylindrical shaft of the column and the square bed of the impost.(14). Then a capital is only an ornament, but is a useful member of the construction. (Art. Chapiteau).

Had the Romanesque constructors a crowning cornice to be placed on the top of an external wall, being economical of time and materials, they carefully avoided cutting at great cost the different members of that cornice in a single stone; for example, they placed projecting corbels in the last course of rubble, and on these corbels they placed a stone slab serving as gutter for the roofing.(Art. Corniche). It is useless to insist more on these details, that will be presented in their places in the course of this work.

explain this method. At A is the row of volutes of the in-  
terior, at B that of the exterior of the architrave with the  
two projections C intended to receive the ends of the fluting  
on which the capital and base. The side pieces having a wall-  
but fluted and being only subject to the effects of the air-  
tension, they are composed of a single row of volutes, as ex-  
posed in Fig. 11 bis, with the projections necessary for the  
the fluting. It is already evident that the Romanesque con-  
struction left in evidence their material means of construction;  
not far from nothing in the case of the wall, support their archi-  
tecture with some, whose foundations are the basis of the  
last chapter. The Romanesque construction is the basis of the  
as capitals; but the projection of the architrave of these capital-  
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circular arch, whose reason cannot be given, the only one in  
shape of the Roman column form is retained, but the circular  
architrave of the order; no great height and active support  
between A and B having nothing, and thus the entire archi-  
tecture has been well suited only for classical and decorative  
construction intended for display and variety. It must be noted  
that this style was very common but an extremely narrow. Thus  
the Romanesque construction placed its arch on an isolated in-  
sulated column, the capital is only a modification of the  
rounding the form of the arch, a modification which is very  
evident between the cylindrical shaft of the column and the  
architrave of the impost. Thus a capital is only an archi-  
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for example, they placed horizontal cornices in the last course  
of masonry, and on these cornices they placed a series of archi-  
tecture for the cornice. (Fig. 14). It is evident  
to realize some of these details, they will be presented in the  
next place in the course of this work.

The construction of the vaults was then the great preoccupation of the architects of the middle ages; as we have just shown, they had reached combinations ingenious in themselves, but had not yet found means suitable to maintain with certainty these vaults, and were reduced to expedients. Thus for example, they constructed the compartments of these vaults in tufa or light materials, so as to diminish the effects of the thrusts, they reduced their thickness as much as possible; they piled masonry beneath the roofs of the side aisles at these thrusts, in the hope of preventing the overthrow of the piers; they placed transverse ties of wood at the buttresses, concealed by the slope of the roofs, to render the piers of the external walls stable. These expedients were sufficient in small structures; in large ones they only lessened the effects of the thrusts without entirely destroying them.

It is unnecessary to take account of these effects to conceive the series of reasonings and of attempts by which constructors passed from ignorance to knowledge. Let (15) be the transverse section of a Romanesque church of the end of the 11th century like that of Vezelay, built with cross vaults over the side aisles and the central nave. At A is represented the construction as conceived by the architect; at B such as the stress in the high vaults had deformed it. Care was taken to leave iron tie rods at C D at the springings of the transverse arches; but these tie rods were probably forged badly and broke. A century and a half after the construction of the nave, the effects produced had already caused the fall of several vaults, and in haste had been constructed the external flying buttresses E dotted in our drawing. These effects were; 1, pushing outward the piers ~~and the walls~~ connecting them between F and G, consequently a sinking of the transverse arches at the crown H, crushing of the beds of these arches at I at the intrados; 2, the dislocation of the transverse arches of the side aisles, as our Fig. indicates; and consequently pushing outward the external walls of the side aisles. These effects were produced everywhere in the same manner. In studying them, the constructors believed and not without reason, since the fact was constant, that all the evil was produced by the thrust of the round arches and the vaults they partly supported; that the too flat concavity of these vaults



had an oblique action, too great a thrust, that the thrust of a round arch increased directly by its action; that the deformation suffered by these arches indicated their weak points, viz; the crown and haunches, that always when a round arch is perfectly abutted, and the piers supporting it spread apart, these arches are deformed, as indicated by Fig. 16.

Let a vault have a diameter of the transverse arches of 23 ft., the depth of the voussoirs of these arches being 2.4 ft.; the walls then moving outward at the springings, of these arches about 0.66 ft. each, then the diameter of the semicircle with centre at B becomes 24.3 ft., and the points a of the springings of the transverse arch moved out at a'. The arc a b, a little less than a quadrant, becomes a'b'; for assuming that the pier breaks and pivots at a point 9.8 ft. below the springing a, and the centre B will rise to b'. The consequences of this first movement will be; 1, the lowering of the crown D to d and the sinking of the arc b c to b'c'. This effect will continue until the moment when the diagonal curve b e, traced from the intrados to the extrados of the arc b c, will be shorter than the distance between b' and e'. It must be noted in passing, that Romanesque vaults, assumed to have been constructed elliptical, only acquired that curve because of the spreading of the piers. A spreading of 1.3 ft. between these piers from the verticals gives 1.3 ft. of sinking at the crown of the arch; the difference in that case between the half diameter of the arch and the rise of the curve is then 2.6 ft. Constructors must have observed these effects and have sought means to prevent them. The first means that they appear to have employed is this; having a nave whose transverse arches are 23. ft. diameter at the intrados and voussoirs 2.0 ft. deep, and having noted (Fig. 16), that the arc b'c' in sinking pressed the lower arc a'b' at the intrados at b', and the crown at the extrados at e', they concluded that the curvilinear triangle b'a'c) was useless, and that the diagonal b'e' alone offered resistance; then starting from this principle, they traced (17) the two semicircles of the intrados and extrados A B C, D E F; then they sought the centre O of a circular arc connecting the point A of the intrados with the point E of the extrados of the round arch placing a joint at E G and not a keystone, to avoid the effect of equilibrium visible in Fig.



16, they jointed the voussoirs of this new arch according to the normals of the curve A E, i.e., radiating from the centre O. If cracks were again produced in these transverse arches, thus composed of two diagonal curves A E, the constructors proceeded with the arch A E as with the round arch, i.e., they moved the centre O to O' on the diameter, so as to obtain an arch connecting the point A with the point G.

Thus in the vaults of the 12th century, we see the transverse arches gradually diverge from the round arch to approach the equilateral arch. The best proof that we can give in support of our hypothesis is the exact measurement of a great number of these broken primitive arches, which give accurately a rise greater than the half diameter by once, twice or thrice the depth at the impost. But this proof is only evident to those who have accurately measured a great number of transverse arches of that epoch. Here is a general observation, that can be made by everyone, without recourse to measurements made with difficulty.

There are provinces, for example like Ile-de-France, where Romanesque round transverse arches have but small depth of voussoirs. Now these in the first vaults having broken arches, the pointing of these arches is scarcely sensible, while in provinces where the Romanesque round arches have a strong depth as in Burgundy, the pointing of the transverse arches of the first vaults abandons the round arch, and is much more marked.

The adoption of the broken (pointed) arch was thus the result of the observations the constructors had made of the deformation of round arches, viz.; the rising of the haunches and the sinking of the crown, which exist in a great number of transverse arches of the 12th century traced as indicated in Fig. 18, i.e., with four centres; two centres A for the partial arcs B C, D E, and two centres G for the partial arcs C D, comprising the haunches; this to present from C to D a greater resistance to the effect of rising felt between the points C and D; for the more nearly the line C D approaches a straight line, the less subject is it to break from within outwards; by this trace the constructors avoided giving transverse arches a sharpness, that could not fail to shock those accustomed to the round arch.



From the moment that the transverse arch composed of two circular arcs came to replace the round arch, there resulted from that innovation a multitude of consequences, which must carry the constructors far beyond the aim, that they claimed to attain. The broken or pointed arch (since this is its true name) employed as a means of construction, required by the observation of the effects resulting from the thrust of round arches, is an actual revolution in the history of the art of building. It has been stated; "the constructors of the middle ages invented nothing in adopting the pointed arch, there are pointed arches in the oldest monuments in Greece and Etruria." The section of the treasury of Atreus at Mycenae gives a pointed arch, etc." That is true; yet is always omitted a very important point; this is that the stones composing these arches are corbelled; that their beds are not normal to the curve but are horizontal; that is less than nothing for those occupying themselves only with the external form; but for us practitioners, this detail has its importance. Besides when the Greeks or the Romans would build vaults generated by pointed arches, how could that be done if the general principle of construction was not derived from the combination of these curves and the observation of their oblique effects? It is evident that from the day when man invented the compasses and the means of tracing circles, he discovered the pointed arch; what matters it to us if he did not establish a complete system on the observation of the properties of these arches? Men have also desired to see in the use of the pointed arch for the construction of vaults a symbolical or mystical idea; they have pretended to demonstrate, that these arches had a sense more religious than that of the round arch. But men were entirely as religious at the beginning of the 1<sup>st</sup> century as at its end, if not more so, and the pointed arch appeared just at the moment when the spirit of analysis, or the study of the exact sciences and of philosophy commenced to germinate in the midst of a society until then almost theocratic. The pointed arch and its consequences carried into construction appeared in our monuments, when the art of architecture was practised by laymen, and left the enclosure of the cloister, where until then it had been exclusively cultivated.

The last Romanesque constructors, those that after so many

From the moment that the architect with compass and straight-  
edge came to replace the round arch, there resulted  
from that innovation a multitude of consequences, which must  
carry the consequences far beyond the arch, and which must  
be stated. The problem of the arch is not only a problem  
of construction, but a problem of organization, and the  
organization of the effects resulting from the thrust of round  
arches, is an actual revolution in the history of the art of  
building. It has been stated: "The consequences of the arch  
were limited in scope in the oldest monuments in Greece and Persia."  
The history of the arch at Athens at Mycenae gives a point  
of view, etc. That is true; yet it is always omitted a very im-  
portant point; this is that the stones composing these arches  
are not really that their beds are not normal to the curve of  
the arch itself; that is less than nothing for those con-  
sidering themselves only with the external form; but for as con-  
sidering, this detail has its importance. Besides when the Gr-  
eeks or the Romans would build vaults generated by pointed a-  
rches, they would not do so as the Persians did.  
Construction was not derived from the combination of these  
curves and the observation of their optical effects? It is  
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ticed by heaven, and left the enclosure of the cloister, wh-  
ere until then it had been exclusively cultivated.  
The last consequence of the arch, which is that it has

experiments had come to reject the round arch were not dreamers; they did not reason upon the mystical sense of a curve; they knew not whether the pointed arch was more religious than the round arch; they built, which is more difficult than to think with an empty head. These constructors have to support wide and high vaults on isolated piers; they tremble at the removal of the centering of each bay, they daily apply a palliative to the apparent evil; they observe with anxiety the least movement, the least effect produced, and that observation is an incessant and fruitful instruction; they have only vague and incomplete traditions, obscurity is around them, the monuments they build are their only models; on them they make experiments; they have recourse only to themselves, respecting only their own observations.

When one thoroughly studies the structures built at the beginning of the 12<sup>th</sup> century, succeeds in classifying them chronologically, and follows the progress of the principal schools that built in France, Burgundy, Normandy and Champagne, one is still seized today by that sort of fever that possessed the constructors, sympathizes with their anxiety, their haste to reach a safe result; applauds their perseverance, the truth of their reasoning, the development of their knowledge, so limited at first, soon so profound. Certainly such a study is useful for us, constructors in the 20<sup>th</sup> century, who are disposed to take appearance for reality, and who frequently place vulgarity in the place of good sense.

Already at the beginning of the 12<sup>th</sup> century, the pointed arch was adopted for the great tunnel vaults in a part of Burgundy, Ile-de-France and Champagne, i.e., in the provinces most advanced and most active, if not richest. The high naves of the churches of Beaune, Saulieu, Charite-sur-Loire, the Cathedral of Autun, are covered by tunnel vaults formed of two intersecting circular arcs, although <sup>in</sup> these same monuments the archivolts of doorways and windows remain round arches. It is a necessity of construction that imposes the pointed arch in these edifices, and not a particular taste; for a remarkable fact, all architectural details of these monuments reproduce certain antique forms borrowed from the Gallo-Roman edifices of the province. Thanks to that innovation of the pointed arch applied to tunnel vaults, these churches have r

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remained standing until our days, ~~not without having suffered~~ disorders sufficiently serious to require two centuries later the use of new means suitable to prevent their ruin.

But the edifices in which one finds the transition from the system of Romanesque construction to that called Gothic is the porch of Vezelay. This porch is by itself alone a monument composed of nave with three bays and side aisles with vaulted galleries above. The plan of this porch, built about 1150,<sup>1</sup> is entirely Romanesque and does not differ from that of the nave, erected fifty years earlier; but its section presents notable differences from that of the nave. Already about the end of the 11 th century, the constructors of the nave of the church of Vezelay had made a great advance by replacing the high vaults by cross vaults, previously being tunnel vaults; but these vaults on oblong plans generated by round transverse and side arches, show experiments, uncertainties and the inexperience of the constructors. (Art. Architecture Religieuse, Fig. 21). In the porch all arches are pointed, vaults are cross vaults without projecting groins, and are constructed of rough rubble plastered; the high vaults are very skilfully abutted by those of the galleries of the first story. This entirety presents a perfect stability.

Note 1.p.31. It must be stated here, that Burgundian architecture was at least 25 years behind that of Ile-de-France; but the monuments of the transition are lacking in Ile-de-France. The church of S. Denis was built about 1140, already nearly Gothic in system of construction, and the edifices intermediate between that and those frankly Romanesque no longer exist, or were entirely modified in the 13 th century.

We give (19) the transverse section of the porch of Vezelay; the vaults of the galleries are generated by the side arches A of the great vaults, which are actual archivolts, and by the side arches B with much longer springings; hence the inclination A B of the crowns of the lateral vaults, that form a continuous abutment securing the great vaults. The bays being oblong and the side arches springing from the same level as the transverse arches C, the crown A of these side arches is at a level below the crowns of these transverse arches; the great vaults by reason of that arrangement are very much raised, and their projecting groins are scarcely apparent. At D'



we have represented the detail of the imposts of the arches at the level D of the pier, and at G is the plan with the lines of the arches and the groins of the vaults. This construction of vaults nowise resembles Roman construction, already the independence between the different parts of the structure is admitted and developed.

Yet the vaults of the porch of Vezelay, excepting two, are without groins or projecting groin ribs, they hold only by a adhesion of the mortar and each forms an homogeneous and concrete cavity, like the Roman vaults. The sole two vaults of this porch possessing groin ribs could do without them; these are merely a decoration and only supported actually by the rubble compartments. But this was an experiment, that soon had important consequences. Constructors had already obtained by means of transverse and side arches, independent and resistant for each vault, a sort of elastic skeleton on which, if settlements occurred, these vaults could move independently of each other. They wished to go farther, they desired the concave triangles of these vaults to be independent of each other, and for this they composed the vaults of two very distinct elements, the arches and the compartments. the arches are regarded as permanent centres of the compartments, as neutral concavities destined to close the triangles left between the arches. They commenced by avoiding a primary difficulty, which until then had always troubled the architects; they returned to the vault on a square plan, comprising two oblong bays, if necessity required; i.e., they traced their vaults in horizontal projection as indicated in Fig. 20.

Let A B C D be a square, exact or nearly so matters little, comprising two bays of the nave, A E B F, E C F D, the diagonals A D and A C generate the vault; these two diagonals are the diameters of two exact semicircles, revolved into the plan; these two semicircles having the same diameters will necessarily intersect at the point G, the master crown. Taking a distance = radius G A and laying it off on the perpendicular G I, the pointed arch E I F is so traced that the point I falls on the point G; this is the transverse arch whose horizontal projection is E F. Taking a distance less than the radius G A, but greater than half the width A B of the nave, and laying it off on the perpendicular H K, the pointed arch A K B is traced; this is the transverse arch, whose horizontal projec-



projection is A B or C D. Finally, taking a distance I M less than the line H K and greater than half the line B F, the pointed arch B M F is drawn; this is the side arch, whose horizontal projection is B F, F D, etc. Putting these centerings in wood according to the four curves revolved on the same line O P (20 bis), stone arches with extradosses are turned on these centerings, obtaining the skeleton of the vault represented by Fig. 21.

These are the primitive vaults termed vaults with groin ribs. One will note that these vaults are generated by a semicircle, which at first supplies the diagonals; the semicircle determines the heights of the pointed arches. Then it may be said in passing that the groin arches (such are termed the diagonal arches) are round; which indicates that the word groin is not suitable for the pointed arch. But this is not the time to discuss words (Art. Ogive), and our remark is only made here to indicate one error among so many others, on which basis one frequently judges an art that he knows badly. The pointed arch had been adopted by the last Romanesque architects, as we have seen above, to diminish the effects of thrusts. Its part is now extended, and it becomes a practical means for closing vaults, whose actual generatrix is the round arch.

When (22) a cross vault is generated by two cylinders intersecting at a right angle, the arches A B, C D; A C, B D, are round and the intersections A D, B C are depressed arches, since the crown E does not exceed the level of the crown F, and the diameters A D, B C are longer than the diameters of the semicircles A B, C D. That is not dangerous, if the vault A B C D is homogeneous and solid, if it forms a shell in a single piece like the Roman vaults. But if the constructor desires to preserve a certain elasticity in the triangles of his vaults, if he wishes the diagonal groins A D, B C to be ribs, and if he desires the triangles A B E, C D E, A C E, B D E, to rest on these ribs as on permanent centerings, and this vault has a great span, then one conceives that it would be imprudent to trace the diagonal arches A D, B C, that fulfil such an important function, in a curve less than a semicircle. If such a trace be not absolutely contrary to good construction, at least it presents difficulties in execution, either to find the points through which these depressed curves



must pass, or in the cutting of the voussoirs. The round arch avoids these and is incomparably more stable. The first constructors of frankly Gothic vaults do something apparently very simple; instead of tracing a round arch with the diameter A B like the Roman constructors, they traced it with the diameter A D. This is actually their sole innovation, and we believe that they did not suspect the consequences of a fact apparently so natural. But in the essentially logical art of the constructor, based on reasoning, the least deviation from accepted principles rapidly brings the rigorous consequences, that take us very far from the point of starting. It must be stated that the first Gothic constructors were justly repelled by the experiments of Romanesque constructor, that mostly ended in deceptions, but were not frightened by the results of their new methods, yet on the contrary with rare sagacity sought to profit by all the resources that they offered.

The Gothic constructors did not invent the pointed arch; it existed, as we have already seen, in structures whose system was frankly Romanesque. But the Gothic architects applied the pointed arch as a system of construction of which they were indeed the sole and actual inventors. There were pointed arches in the 12 th century in all western Europe. There was no Gothic construction at that epoch, except in a small portion of the actual area of France, however this may displease those, who do not admit, that anything was invented among us before the 16 th century.

It is with the pointed arch as with all inventions in this world, that are in a latent state quite before receiving their true application. Gunpowder was invented in the 13 th century; it was actually employed only in the 15 th, because the moment had come when this agent of destruction found its application necessary. It is the same with printing; stamps were made from all time; but the idea of combining letters of wood or of metal and of printing books only came when many persons could read, when a knowledge and instruction was distributed among all classes, and were no longer the privilege of some clerics shut up in their monastery. Leonard de Vinci, and perhaps others before him, foresaw that steam would become a motive force easily employed; yet steam engines were only made in our times, because the moment was come, when that agent by



its power was alone capable of sufficing for the needs of our industry and our activity. It is then puerile for us to say, that the pointed arch being in all times, the constructors in the 12 th century merely claimed its invention. Certainly, they did not invent it, but they employed it in accordance with its qualities, and the resources it presented in construction; and we repeat that only in France, i.e., in the royal domain and some adjacent provinces, did they know how to apply it to the art of building, not as a form chosen by caprice, but as a means of causing to prevail the principle, whose serious and useful consequences we are to seek to make known.

If in adopting the round arch for the diagonals of vaults, constructors at the end of the 12 th century had desired to apply it to transverse and side arches, they would first have had to make a step backward, since their predecessors had adopted the pointed arch after sad experiences, as having less thrust than the round arch; they they would have found themselves much embarrassed in closing their vaults. Indeed the crowns of the transverse and side arches traced as semicircles would have been found above the level of the crowns of the groin arches, so that it would have been difficult to fill the compartments with rubble, and that if closed, the appearance of these vaults would have been very disagreeable and their thrust considerable, since they would have been composed at first of round transverse arches with the enormous load, that the rubble compartments would have added. On the contrary, the advantage of the pointed arch adopted for the transverse arches in cross vaults is, that only to thrust very little by itself, but also to suppress a great part of the load of the rubble compartments, or rather to render this load nearly vertical. Indeed, let (23) be the plan of a cross vault, if the arches A D, C B be round and the transverse arches A B, C D are also round, revolution of these arches will give for the groin arches a semicircle E F G, and for the transverse arch the semicircle E H I. In that case filling the triangle C O D with rubble will load the circular arch K H L, i.e., a about three fifths of a semicircle. But if these transverse arches are traced like the pointed arch E M I, filling the triangle C O D with rubble will only load the portion of that arch comprised between P M R, the points P and R being given

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 arches situated between F M R, the points F and R being given

by the tangent  $S T$  parallel to the tangent  $V X$ , and the portions of the compartment between  $E R$  and  $I P$  will alt vertically. If the transverse arches be semicircles, the oblique load on each triangle of rubble will be  $O N, Q, Q', N'$ ; while if traced pointed as indicated in our Fig., that load will be only  $O N Y, Y', N'$ .

The experimental method suffices to give these results, and at the end of the 12 th century, constructors had no other. It is for us to demonstrate the accuracy of this method.

We have just stated, that the point  $K$  at which commences the load of the compartment gives an arc  $I K$ , which is about one fifth of the semicircle. Now (24) let  $A B$  be a quadrant,  $O C$  a line drawn at  $45^\circ$  degrees dividing this quadrant into two equal parts, the voussoirs from  $C$  to  $B$ , if not supported by the pressure of the other voussoirs from  $B$  to  $D$ , would overturn by the laws of gravity, and consequently would thrust against the voussoirs between  $A$  and  $C$ . Then is  $C$  where the rupture of the arch occurs; but account must be taken of the friction of the surfaces of the voussoirs and of the adhesion of the mortar. That friction and adhesion suffice still to maintain in its plane the voussoir  $F$  and to make it stable on the lower voussoir  $G$ . But the voussoir  $F$  participating in the weight of the voussoirs between  $F$  and  $B$  affects the voussoir  $G$  and sometimes one or two below the point at which the beds of the voussoirs give an angle of  $35^\circ$  degrees, which is a little less than one fifth of the semicircle. Only above that point can rupture occur, when it must (Fig. 16), and consequently that the active load commences.

Whether the calculation be theoretical or practical, it is certain that the constructors of the 12 th century counted for a moment to sufficiently reduce the thrusts of vaults to omit the abutments, and to maintain them on piers of moderate thickness, provided that they were loaded; for at first they did not think it necessary to oppose flying buttresses to thrusts, that they believed they had neutralized, either by the obliquity of the groin arches, or by the pointed curve of the transverse arches. Yet experience soon demonstrated to them, that they were mistaken. The resultant of the oblique thrusts of these round groin arches, added to the thrust of the pointed transverse arches, was strong enough to overturn piers very



high above the ground, and that were merely struts without bearing. Then they placed flying buttresses, and at first only at the junctions A of the three arches (25), omitting them at the points B receiving the isolated transverse arches. But what level should be reached by the head of the flying buttress? There was a difficulty, greater because theoretical calculation does not give exactly that point, and that only long experience can indicate. As far as one can judge of this by the small number of primitive flying buttresses preserved, here is the method pursued by the architects.

Let (26) A B C be the transverse arch separating the great vaults; also let from the centre D of the arc A B be drawn a line D E at an angle of  $35^{\circ}$  degrees with the horizon; let F G be a tangent at the point H; let A I be the thickness of the wall or pier; the tangent F G will cut the external line I K of the pier at the point L. That point gives the intrados of the voussoir at the head of the flying buttress. That arch is then a quadrant or a little less, its centre being placed on the line K I prolonged or a little inside that line. The load M N of the flying buttress originally is quite arbitrary, small at the top M, greater over the haunch at N, which gives a small inclination to the upper line N M. Soon effects appeared in that construction because of the thrusts of the vaults and in spite of these flying buttresses; this is the reason; behind the haunches of the arch and vaults at T were built masses of bastard masonry, as much to load the piers as to maintain the haunches of the arches and the compartments. These masses indeed had the advantage of preventing rupture of the arches at the point H; but the entire load of the compartment acting from K to O, and that load being considerable, there resulted a small rise at the crown B, the arch being loaded from O to B, and consequently a deformation indicated in Fig. 26 bis. This deformation produced a rupture at the point O', a level above the mass, consequently a very oblique thrust O'P above the head of the flying buttress. Here the laws of equilibrium were broken. Hence it was necessary to rebuild all the flying buttresses of the primitive Gothic monuments some years after their construction; and then men were satisfied by raising the head of the flying buttress, or this was doubled by a second arch. (Art. Arc-Boutant).



It is seen that we do not conceal the false movements of these constructors; but like all entering a new path, they could only reach their aim after many trials. It is easy today, when we have monuments built with care and knowledge, like the cathedral of Amiens or that of Rheims, to criticize the attempts of the architects of the end of the 12 th century; but at that epoch when only existed Romanesque monuments of small size and very badly constructed, when the exact sciences were scarcely foreseen, the new task imposed on themselves by the architects bristled with difficulties recurring continually, that one could succeed only by a series of observations made with the greatest care. These observations formed the skilful constructors of the 13 th and 14 th centuries. It must be said in praise of the architects, that having adopted the new principles of construction, without precedents, they pursued the developments with a tenacity and a rare perseverance, without looking backward, in spite of the difficulties, that arose at each opportunity. Their tenacity is the more honorable in that they could not foresee, in adopting the principle of construction of Gothic vaults, the consequences naturally arising from that system. They acted as do men moved by a strong conviction, they opened for their successors a broad and sure way, in which western Europe could march without obstacles for three centuries. Every human conception is stained by some error, and the truly immovable in everything is yet to find; each discovery bears in its bosom in seeing the light the cause of its ruin; and man has no sooner adopted a principle, than he recognizes its imperfection and defect; his efforts tend to oppose the defects inherent in that principle.

Now all conceptions of the human mind, the construction of edifices is one of those finding itself in presence of the most serious difficulties, because they are opposed natures, some material, the others moral. Indeed not only must the constructor seek to give the materials employed the most suitable form, according to their special nature; he must assemble them so as to resist the different forces, external agents; but again he is compelled to submit to the resources at his command, to satisfy the moral needs, to conform to the tastes and the customs of those for whom he builds. These are the d

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difficulties in conception, the efforts of intelligence of the artist; there are again the means of execution from which the constructor cannot free himself. During the entire Romanesque period the architects had made vain attempts to harmonize two principles that seemed irreconcilable, viz:—slenderness of vertical points of support, economy of materials, and the use of the Roman vault more or less changed. Some provinces had adopted pure Byzantine construction, because of influences foreign to the western spirit.

At Perigueux was built after the end of the 10th century the church of S. Front; from this isolated example started the school. But it must be recognized that this sort of building was foreign to the new spirit of the western peoples, and the constructors of S. Front of Perigueux erected that church, as might modelers reproducing forms with texture unknown to them. Thus for example, the pendentives supporting the domes of S. Front are constructed by means of courses set corbelled with beds not normal to the curve, but horizontal; if these pendentives do not fall in, this is because they are maintained by the mortar and adhere to the masses before which extends their concave surface. In similar structures, one sees no more than an attempt made to reproduce forms, whose geometrical reason is not understood by the constructors. Besides complete ignorance, pitiable expedients, applied well or badly at the moment when the difficulty presents itself; but no foresight.

There are a great number of Romanesque structures, that indicate a complete lack of foresight on the part of architects. Some monument is begun with the vague idea of terminating it in a certain manner, which remains half finished, the constructor not knowing how to solve the problem he has set himself; another can be completed only by the use of means evidently foreign to its primary conception. It is seen that the primitive Romanesque constructors built day by day relying on inspiration, by chance and according to circumstances, perhaps even counting on a miracle to perfect their work. The legends attached to the construction of great edifices (were the monuments not there to show us the embarrassment of the architects) are full of dreams in which these architects saw some angel or saint, taking the trouble to show them how they

foreign to the western world.

should build their vaults, or maintain their piers; which does not always prevent those monuments from falling soon after their completion, for faith does not suffice for building.

Perhaps without being less credulous, the architects of the end of the 12th century, mostly if not all laymen, thought it prudent in the matter of construction to not expect the intervention of an angel or saint in erecting an edifice. Thus (a curious fact meriting mention) the chronicles of monasteries, legends and histories, so lavish of praise for the monuments built during the Romanesque period, that enlarge so complacently on the beauty of their construction, their grandeur and decoration, although many of these monuments are only bad structures of rubble badly conceived and worse executed, are abruptly silent at the end of the 12th century, when architecture passed from the cloisters into the hands of laymen. By chance is a word of the edifice, a dry and laconic phrase; nothing of the master's work.

For example, is it credible, that in the voluminous register of Notre Dame of Paris, that comprises documents dating in the 12th century, not a single word is said of the construction of the existing cathedral? Laborious and intelligent architects came from the people, who were first able to free them from effete traditions; who had frankly entered into practical science; who formed that army of skilful workmen soon scattered over the entire surface of the western continent; who opened the way to progress, to bold innovations; finally, who belonged in so many ways to modern civilization; who first possesses its spirit of research, its need of knowledge; if their attempts allowed their names to be forgotten; if scorning efforts by which they profited, those pretending to direct the arts of our time endeavour to traduce your works, at least among so many past and present injustices, our voice rises to reclaim the place belonging to you, and that your modesty lost to you. If less preoccupied by your labors, you had made your science valued like your colleagues of Italy, had boasted of your own genius, we should not be compelled today to search in your works to bring to light the profound experience acquired by you, your practical means so judiciously determined, and particularly to defend you against those incapable of comprehending, that genius may develop in the shadow; that it is of its essence itself to seek <sup>the</sup> silence of obscurity; against

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 to you. If less preoccupied by your labors, you had more your  
 esteem, valued like your colleagues of today, and instead of  
 your own names, we would not be compelled today to search  
 in your works to find in light the profound significance of  
 not by you, your practical sense so immediately felt, and  
 and particularly to thank you, whose names are known to all  
 construction, that which was devoted in the 12th century to the  
 of the human mind to the science of knowledge; without

so great a number, who judge by faith in decisions rendered by passion or interest, and not after their own examination.

Yet it must be stated; it is no longer permitted today to decide questions in history those concerning the arts, politics or literature, but simple affirmations or denials. And retrograde minds are those desiring to judge these questions by relying on old methods or on their prejudices. There is no sensible artist, who dares to assert that we should construct our edifices and our houses as done in the 12<sup>th</sup> or 13<sup>th</sup> centuries; but each just mind can understand, that the experience acquired by the masters of that time could be useful to us, so much the more as these masters innovated. The most difficult obstacle for us to overcome, the real and living obstruction, it must be confessed, is indolence of the mind; everyone wishes to know without taking the trouble to learn, and pretends to judge without knowing the documents in the case; the truest principles, best written and most useful, will be placed among old ideas out of use, because a witty man has derided them; and the listening multitude is too happy to applaud a criticism, which avoids the trouble of learning. A sad glory after all, which consists in prolonging the duration of obscurity; it cannot profit him, who acquires it in an age that boasts of casting light on everything, whose activity is so great, that not being able to find in the present sufficient food for its intellectual needs, it even desires to unroll the past before itself.

If in the eyes of persons who have studied it with care and have brought into that study an enlightened criticism, our French architecture of the Renaissance is superior to the Italian architecture of the 15<sup>th</sup> and 16<sup>th</sup> centuries, does not that come from the fact, that our Gothic schools, in spite of the abuses of the later time, long formed skilful workmen and intelligent constructors, knowing how to subject the form to reason; so these schools were particularly suitable to free the spirit of architects and workmen, to familiarize them with the numerous difficulties surrounding the constructor? We know that this language cannot be understood by those, who judge the different forms of our art according to their feelings and their prejudices; hence we do not address those persons but architects, those long acquainted with the resources for the

an artist a number, who judge by faith in decisions rendered  
by himself as interest, and not after their own examination.  
But it must be stated; it is no longer detailed today as  
decisions rendered in scientific manner concerning the mind, and  
its relation to the physical attributes of the body, and  
theosophical minds are those desiring to judge these questions  
by relying on old records or on their own judgment. There is no  
scientific aspect, but after to himself and his social environment  
our offices and our houses as done in the 15th or 16th cen-  
tury; but now that kind can be understood, that the scientific  
accounted by the manner of their mind could be useful to us, we  
know the mind as some certain movement, the mind itself  
operates for us to overcome, the real and living construction,  
it must be confessed, is influence of the mind; everyone wishes  
to know without taking the trouble to learn, and creates  
to find without knowing the knowledge to be gained, the result  
of this, that which is not useful, will be of no use to  
all ideas out of use, because a writer has been denied them;  
and the scientific attitude is not known to science as a method  
and, which avoids the receipt of knowledge, but only what  
all, which contains in knowledge the objects of knowledge  
it cannot profit him, who acquires it in an abstract process  
of seeking light on everything, whose activity is so great,  
that not being able to find in the present sufficient food  
for his intellectual needs, it even begins to devour the one  
before itself.

It is the eyes of persons who have studied it with care and  
have brought into study an enlightened criticism, our  
theoretical architecture of the Renaissance is superior to the  
other architecture of the 15th and 16th centuries, does not  
lose sight of the fact, that the Renaissance is superior to  
the abuses of the later time, that formed a skillful person and  
independent constructors, knowing how to subject the form to  
reason; we these schools were particularly suitable to free  
the spirit of architects and workers, to familiarize them with  
the scientific difficulties, the construction of the  
body with the mind, and the construction of the mind with the  
body, and the body with the mind, and the mind with the body,  
and the body with the mind, and the mind with the body, and  
their practices; hence we do not address those persons but  
the scientific, those that understand with the scientific

difficulties presented by the practice of our art. Certainly for artists the study of ~~an art~~ where all is foreseen and calculated, which even sins by excess of investigation and of practical means, in which matter is both master of form and subject to principle, cannot fail to develop the mind and to prepare it for the innovations required by our time.

It would be to leave our subject to explain how at the end of the 12 th century was formed a powerful school of constructors; how that school was protected by the episcopate, which desired to reduce the importance of the religious orders, possessing the sympathy of the people from which it sprung, and reflecting their spirit of progress and research, accepted by the secular nobility that did not find in the monks all elements needed in building its habitations; how that school may be said to profit by favorable circumstances and strongly established itself, and by that acquired a great independence. It will suffice for us to indicate that state of things, new in the history of the arts, to cause the consequences to be appreciated.

We have already seen where constructors had arrived about 1160, how they had been led to modify successively the Romanesque vault, which was only a degenerate tradition of the Roman vault, and to invent the so-called cross vault. This great advance having been made, there remained much still to be done. The first result of that innovation was to compel constructors to design their edifices by commencing with the vaults, and consequently to leave no more anything to chance, as too frequently occurred to their predecessors; that method appears strange, but consists in drawing the ground plans from the projected construction of the vaults and is eminently rational. What end is it proposed to attain? to establish vaults on points of support. What is the principal object? The vault. The points of support are only the means. Roman constructors had already been led to derive the plans of their vaulted edifices from the form and extent of those vaults themselves; but that principle was only general, and from the examination of a Roman plan of the late empire, one cannot always conclude that such a part had a tunnel vault, a cross vault or a portion of a sphere, as each of these vaults could be placed indifferently on these plans in many cases.

difficulties presented by the practice of our art. Certainly for artists the study of anatomy is all the more necessary and of course, since even since the days of investigation and of scientific means, in which matter is born master of form and subject to scientific, science will be finding its way and its

separate it for the innovations required by our time. It would be to leave our subject to explain now at the end of the 19th century was formed a powerful school of comparative anatomy and that school was protected by the scientific, which we have to reduce the importance of the religious cases, possessing the anatomy of the people from which it sprung, and reflected their spirit of progress and scientific, science by the people's anatomy that the end is in the hands of all elements needed in building the edifice; the first general law we have to write by favorable circumstances and especially established itself, and by that means a great intellectual it will suffice for us to indicate that state of things, not in the history of the art, to cause the consequences to be anticipated.

We have already seen where constructors had arrived some time, and may not have led to really successive the former and latter, which was only a temporary extension of the same, and to invent the so-called cross vault. This great advance having been made, there remained much still to be done. The first result of that invention was to connect constructors in building their edifices by connecting the vaults, and continuously to leave no more anything to chance, as too frequently occurred in their construction; that would be the

strange, but consists in drawing the ground plans from the projected construction of the vault and its eminently rational. All that now is to proceed to stating to establish vaults on systems of supports. What is the structural object? The vault. The object of support are only the means. Roman constructors had already seen that to have the plan of their vaulting different from the plan and extent of their walls. The vaulting was not continually and only horizontal, and from the vaulting of a Roman plan of our time, we have seen the vaulting of a vault such a part and a tunnel vault, a cross vault or a vault of a vault, as each of these vaults would be almost perfectly on these plans in many cases.

It was not so in the 12 th century; the horizontal plan not only indicates the number and the form of the vaults, but even their different members, transverse, side and diagonal arches; and these members in turn determine the arrangement of vertical points of support, their relative height and diameter. From which one must conclude, that to trace definitely the ground plan and proceed to the execution, it was necessary first of all to make a diagram of the vaults, of their heights and springings, to know accurately the dimensions and forms of the voussoirs of the different arches. The first Gothic constructors so quickly became familiar with this method of taking all construction by its top in order to successively trace its bases, that they adopted it even in edifices not vaulted, but with floors or carpentry, they no longer found it bad, as we shall see later.

The primary condition for establishing the plan of an edifice at the end of the 12 th century being to know if it must be vaulted, it is then necessary when the number and direction of the arches of these vaults are known, to obtain the trace of the springings on the capitals, for the trace of the springings will give the form and dimensions of the abacuses of the capitals, the number, strength and location of the vertical supports.

Then assuming the hall (27) having to be vaulted, 39.4 ft. in the clear and composed of bays 19.7 ft. between axes. Adopting the system of cross vaults crossed by a transverse arch according to the method of constructors at the end of the 12 th century. It is necessary to trace the lower bed of the springings of the arches starting at A'B, and to know the width of the voussoirs. We admit that these voussoirs for a hall of that extent must have 1.3 ft. in width and height; we recognize that at that epoch the different arches of the vault are turned with voussoirs similar in diameter and form. We also recognize that the side arches spring considerably higher than the transverse and groin arches, the little columns serving to support them frequently exceeding the level of the diagonal and transverse arches; that in tracing the bed of the impost of the transverse and diagonal arches, we must take into account the passage of the little column supporting the side arch, as we take account of the side arch itself. Let



(28) be the detail of the horizontal trace of the springing of the arch at B; at this point spring only a transverse and two side arches. These determine, for it is necessary for the transverse arch to separate from the side arches at its impost. Let A B be the face of the wall; the side arch usually has a projection of half the width of the diagonal arch or of the transverse arch, when these two arches have similar sections, or half the diagonal arch when that and the transverse arch have different sections. In the present case, the side arch has a projection of 0.7 ft. from the face of the wall. At C we draw a line parallel to A B. The axis of the transverse arch being D E, points F and G being taken each at 0.7 ft. from that axis, we draw the two parallels F I, G K, which give the width of the transverse arch. Laying off 1.4 ft. from F to I', we have its depth between the extrados and intrados; we can then trace the proper section in the square F I'K'G; this is the lower bed of the impost. Either the column bearing the side arch rises above the level of this bed as indicated at L, or as sometimes <sup>1</sup> happens, the side arch springs from the capital supporting the transverse arch; then laying from the axis D E 1.4 ft. on the line A B gives us the point M, and we inscribe the section of the side arch in the rectangle E O N M. It is understood that this side arch enters the wall a few inches. The lower bed of the impost being thus found, it is necessary to trace the abacus of the capital, whose profile must form a projection around the imposts of the arches. If the side arch rests on a column rising to its impost as marked at L, the abacus P R S is returned square to die against the little column L of the side arch. If on the contrary, the section of the side arch descends to the capital of the transverse arch, the abacus takes the form P T V X on the horizontal plan. To trace the column beneath the capital in the first case, from the apex R to the right angle of the abacus we draw a line at 45° degrees; this line cuts the axis D E at the point O, which is the centre of the column, and which is given a diameter, such that the projection of the abacus from the shaft of the column must be much greater than the radius of the column. Then there remains between the column and the face of the wall a space, that is filled by a pilaster masked by the column and the little column of the side arch. To trace

(25) In the detail of the horizontal trace of the architrave at the top of the column, at this point, only a transverse and two side arches. These determine, for it is necessary for the construction of the architrave from the side arches at the top of the column, to be the form of the wall; the side arches usually are a projection of half the width of the horizontal trace of the architrave arch, when these two arches have identical outlines, or half the diameter from each side and the transverse arch have different outlines. In the present case, the side arch has a projection of 0.7 ft. from the face of the wall. At the same time, the horizontal trace of the architrave from point B, which is 1.5 ft. from the face of the wall, and the side arches are 1.5 ft. from the face of the wall. From that point, we draw the horizontal trace of the architrave from the side of the transverse arch, which is 1.5 ft. from the face of the wall, and we have the depth between the extrados and intrados; in 1.5, we have the depth between the extrados and intrados; we have then the proper section in the square B T V U; this is the inner bed of the impost. Either the column bearing the side arch rises above the level of the impost, or it is below the level of the impost. In the present case, the side arch rises above the level of the impost, and we have the capital supporting the transverse arch; then having from the axis D E 1.4 ft. on the line A B gives us the point V, and we inscribe the section of the side arch in the rectangle B T V U. It is understood that this side arch enters the wall 1.5 inches. The lower bed of the impost being thus found, it is necessary to trace the arches of the capital, whose profile will form a projection around the impost of the arches. The side arch rests on a column rising to the impost as a capital at U, the arches B T V U is returned square to the capital, and the side arches B T V U of the side arch. If on the contrary, the section of the side arch descends to the capital of the impost, the section takes the form B T V X on the horizontal plane. To trace the column beneath the capital in the present case, from the apex B to the right angle of the arches, we draw a line at 45° to the horizontal; this line cuts the axis B T at the point O, which is the center of the column, and which is given a diameter, such that the projection of the arches from the shaft of the column must be much greater than the radius of the column. Then there remains between the column and the impost a wall a space, that is filled by a diameter marked by the column and the little column of the side arch. To trace

the column beneath the capital in the second case, we take the centre Y on the axis D E, so that the projection of the abacus from the face of the column may be much greater than its half diameter; then the capital forms a corbel or bracket, and is more concaved under the side arch than beneath the face of the transverse arch.

Note 1.p.46. Church of Kestle.

Now take in Fig. 27 the impost A of the two side arches, the two diagonal arches and one transverse arch. Let A B be (28 bis) the face of the wall, C D the directrix of the transverse arch, D F the directrix of the diagonal arch; we trace the projection of the side arch as above. The diagonal arches determine the transverse arch. On each side of the line D E we lay off 0.67 ft. and draw the two parallels F G, H I, which give us the width of the diagonal arch. From the point H, the intersection of the line H I with the axis C D on that line H I, we take 4.44 ft, i.e., a little more than the depth of voussoirs of the diagonal arch, and we draw the perpendicular I G, which gives us the face of the diagonal arch. In the rectangle F G H I we trace the proper section. At both sides of the axis C D likewise taking 0.7 ft., we draw the two parallels K L, M N. From the point H laying off 1.4 ft. on the axis C D from H to C'', we draw a perpendicular L N to that axis, which gives us the face of the transverse arch; we inscribe its section. At P we assume that the column supporting the side arch extends above the imposts of the diagonal and transverse arches as before, that the section of the side arch extends vertically to the abacus of the capital. To trace this side arch in the last case, we take on the line A B 1.4 ft. from the point M to Q, and from the point Q erecting a perpendicular to the line A B, we have the rectangle circumscribing the section of the side arch; the abacuses of the capitals are traced parallel to the faces of the arches as shown by our Figure. From the angles G and L by drawing lines at 45° degrees, we cut the axis D E at O, which is the centre of the little column supporting the diagonal arch, and the axes C D at S, the centre of the column for the transverse arch; we trace these columns according to the rule established before. Behind these detached columns are drawn the returns of the pilasters that strengthen the pier; then the side arch R sta-

The column beneath the capital in the second case, as taken  
the section of the face of the column may be much greater than  
the half diameter; but the section of the face  
and its width measured under the side arch beneath the face

Church of Neale.

Now take in Fig. 27 the mosaic A of the two side arches,  
the two diagonals of the face of the wall, G D the diameter of the trans-  
verse arch, G F the diameter of the diagonal arch; we trace  
the projection of the side arch as above. The diagonal arch  
bisecting the transverse arch. On each side of the line G F  
we take half G F, and from the point H, I, which  
give us the width of the diagonal arch. From the point H, I, the  
bisection of the line H I with the axis G D on that line  
H I, we take half H I, and from the point J, K, which  
bisect the diagonal arch, and we draw the perpendicular  
J K, which gives us the face of the diagonal arch. In the sec-  
tion F G H I we trace the proper section. At each side of  
the axis G D bisect the section G F, and from the point  
L, M, N, from the point L laying off 1.4 ft. on the axis  
G D from the point L we draw a perpendicular to the axis  
which gives us the face of the transverse arch; we inscribe  
an section. At P we assume that the column supporting the ar-  
ch with extends above the capitals of the diagonal and trans-  
verse arches as above, and the section of the side arch is  
the vertically to the apex of the section. To trace this  
with arch in the last case, we take on the line A B 1.4 ft. 1  
from the point M to G, and from the point G erecting a perpen-  
dicular to the line A B, we draw the section of the diagonal  
the section of the side arch; the section of the capital is  
the section of the capital, and from the point L we draw a  
perpendicular. From the angles G and I by drawing lines at 45°  
down, we cut the axis G D at C, which is the centre of the  
diagonal column supporting the diagonal arch, and the axis G D  
is the centre of the column for the transverse arch; we  
draw the section of the column for the side arch, and the  
section of the section of the column are drawn the returns of the  
diagonal that supported the arch; then the side arch is

starts at the face of these pilasters bearing capitals like the columns.

Frequently the side arches do descend to the abacuses of the capitals of the great arches, and only have a little supporting column; they spring from a little column set on the lateral projection of the abacus, as indicated by Fig. 29 in plan and perspective. Then the abacuses of the lateral shafts A were cut so that their oblique face C D, perpendicular to the directrix B of the diagonal arches, was divided into two equal parts by that directrix.

Still it must be recognized, that the constructors only gradually decided to accent the form, the direction and the members of the vaults on the ground plan. They retained for some time the cylindrical piers in the ground story, tracing the plan required by the vaults only on the abacuses of the capitals of these piers. What preoccupied them from the end of the 12th century was the rigorous observation of a principle, which until then had not been imperatively accepted. This principle was that of the equilibrium of forces substituted for the principle of inert stability, so well applied by the Romans, and that the Romanesque constructors vainly endeavored to retain in their great vaulted edifices composed of several aisles. Recognizing the impossibility of giving to detached piers a sufficient bearing to resist the thrust of the vaults, the constructors of the 12th century took a frank part; they sought their means of resistance elsewhere. They no longer desired to accept the detached piers, except only as points of support maintained vertically, not by their own areas, but by the laws of equilibrium. It was then only important that they had sufficient strength to resist the vertical pressure. However, even when a principle is adopted, there are for a certain time in its applications, indecisions and experiments; men never free themselves on the morrow from the traditions of today. Finding the cross vault on a square plan crossed by a transverse arch, the constructors sought again points spaced at alternate bays, more stable because of the principal thrusts. Indeed in Fig. 27, the points A receive the load and resist the thrust of a transverse and of two diagonal arches, while the points B only receive the load and resist the thrust of a transverse arch. This system of construction of vaults,



adopted during the second half of the 12 th century, led the constructors to erect at the points A piers stronger than at the points B, then to give to the voussoirs of the transverse arches resting at A greater width and depth, than those given to the secondary arches; for in the primitive Gothic vaults, it is to be noted, as we have already stated, that the voussoirs of all the arches generally exhibit the same sections.

The pointed arch was so much required by the necessity for diminishing the thrusts or of resisting the loads, that we see in primitive Gothic structures, these arches are only adopted for the transverse arches and the lower archivolts, while the round arch is retained for the window openings, for arcades of galleries and even for side arches, that carry only a small load or have only a small span. At the cathedral of Noyon, whose primitive vaults must have been erected about 1160,<sup>1</sup> the side arches of that epoch are round. At the cathedral of Sens, built about the same times, the side arches are round,<sup>2</sup> while the archivolts and transverse arches are pointed. It is the same in the choir of the abbey church of Vezelay, erected at the end of the 12 th century; the side arches are round. In these edifices and especially at Sens, under the thrusts and combined loads,<sup>4</sup> of the groin and transverse arches, the piers present a very considerable horizontal section compared to a cluster of little engaged columns; while under the load of the transverse arch alone the piers consist of twin cylindrical columns set perpendicular to the axis of the nave. At Noyon the intermediate transverse arches rested on a single column before the rebuilding of the vaults. But the nave of the cathedral of Sens is much wider than that of the cathedral of Noyon, and the construction is stronger at all points. That arrangement of the vaults, comprising two bays and carrying the thrusts and principal loads to the alternate piers, originally allowed the constructors to place flying buttresses only at these principal piers. It is probable that at the cathedral of Sens this was formerly the method adopted; perhaps it was the same at the cathedral of Noyon as at that of Paris. But these edifices having been more or less rebuilt in the 13 th century, it is impossible to affirm anything in that respect. What can be certain, is that at the end of the 12 th century the constructors had only adopted the flying buttress in des-

...the second half of the 12th century, but the  
...to erect at the point A pier stronger than at  
...then to give to the vaults of the transepts  
...A greater width and depth, than those given  
...for in the primitive Gothic vaults,  
...as we have already stated, that the vaults  
...of all the apses generally exhibit the same sections.  
...the pointed arch was not employed in the doorway of  
...the lowest of the choir and transepts, and in the  
...these apses are only adopted  
...the transverse arches and the lower archivolts, while the  
...round arch is retained for the window openings, for arcades  
...of triforium and even for side apses, that carry only a small  
...At the cathedral of Novgorod, the vaults of the choir and  
...must have been erected about 1150, and  
...the vaults of the choir and transepts, and the vaults of the  
...the archivolts and transverse arches are pointed. It is the  
...in the choir of the abbey church of Vézelay, erected in  
...the 12th century; the side apses are round. In  
...and especially at Sens, under the transepts and  
...of the choir and transverse apses, the choir  
...a very considerable horizontal section compared to a  
...rested columns; while under the load of a  
...the choir consists of two cylindrical  
...to the axis of the nave. At No-  
...the intermediate transverse arches rested on a single col-  
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...is much wider than that of the cathedral of  
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...arrangement of the vaults, comprising two bays and carrying  
...the transepts and principal loads to the alternate piers, origi-  
...nally allowed the constructors to place living buttresses only  
...It is probable that at the cathedral of  
...this was formerly the method adopted, because it was  
...the same at the cathedral of Novgorod as at that of Sens. But  
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...it is impossible to affirm anything in that respect.  
...it can be certain, is that at the end of the 12th century  
...the constructors had only adopted the living buttress in des-

despair, that they sought to avoid this as much as possible, that they mistrusted this means, whose advantages and strength they had not been able to appreciate yet; that they regarded it as only an auxiliary, a last resource often applied afterwards, and when they had recognized that they could not omit it. The best proof of this that we can give is, that some years later, the architects having subjected their system of vaults to the system of equilibrium, opposed flying buttresses to the thrusts of vaults, which either were without them or had them only in part, and removed the flying buttresses of the 12 th century, probably badly placed or insufficient, to replace them by new and well combined buttresses with regard to resistance or pressure.

Note 1.p.49. These vaults were rebuilt in the 12 th century over the great nave, leaving the primitive side arches in place.

Note 2.p.49. These side arches were raised at the end of the 13 th century, as may still be seen in the bays of the apse.

Before proceeding farther, it is necessary for us to explain to our readers the procedures in construction, the nature and dimensions of the materials employed. We saw at the beginning of this Article how the primitive Romanesque constructors built their masonry, composed of concrete comprised between facings of cut stone or pointed rubble. The constructors of the 12 th century made some modifications of these primary methods. Building edifices of greater extent and much higher than those of the Romanesque period, seeking to diminish the thickness of the internal supports and the walls, on the one hand it was necessary for them to find a method of construction more homogeneous and more resistant; on the other in monuments already of great height, to avoid the cost of labor, that the hoisting of materials of large volume would have occasioned. Therefore they renounced the use of masonry of large blocks (except in particular cases or in some exceptional edifices), and they preferred construction of small materials, retaining well pointed rubble rather than cut stone.

As much as possible, the greater part of the stones then employed, forming facings, voussoirs and archivolts, of transverse and diagonal arches, are of sufficiently small dimensions to be carried up on a man's back and set by a mason like



our ordinary rubble. The method being adopted, this small masonry is very well executed and judiciously combined; it is a mean between the Roman construction with great masonry and that of concrete faced with bricks or rubble. In adopting small masonry for great edifices, the constructors of the 12 th century had too much sense to set these lower courses of little width with dry joints, like certain Roman structures; on the contrary they separated these courses by beds and joints of mortar (0.4 to 0.8 in. thick), for these joints to form a connection between the internal mass and the facings. This was the Roman method, and it is good. One will indeed understand, that if (30) courses with dry joints are set before a mass of rubble and mortar, the mass tending to settle by the drying of the mortar under the load, and the stone courses set dry on each other not being able to diminish in volume, these will form a vertical rupture A B behind the facings, which will not delay falling. But if (30 bis) we have taken care to leave b between each course of stone a thick bed of mortar, this bed is connected with the mass and will not only retain the stone courses, but again it will permit them to settle equally with the settlement of the internal concrete.

The primitive Roman constructors, particularly in provinces where may be procured large blocks of hard stone, as in Burgundy, Franche-comte and Alsace, on the Saone and the Rhone, have not failed to imitate Roman masonry by setting wide and high slabs with dry joints before the concrete; but they also paid dear for this desire of making their construction other than it was. In most of these edifices appeared ruptures between the facings and the concrete, longitudinal cracks, that occasioned in nearly all buildings at least serious disorders and frequently ruin. These effects were the more frequent and dangerous, as the edifices were higher. Better advised and taught by experience, the architects of the 12 th century, as much by reason of economy and facility in execution, as to avoid this lack of homogeneity of the facings and the mass, adopted construction by very low courses separated by thick beds of mortar. These beds not alone had the advantages of settling and connecting the facings to the mass; made of mortar of fat lime, they hardened quite slowly, and awaiting perfect hardness, the construction had time to settle, to suffer



some deformations, without causing ruptures in the masonry.

The edifices erected from 1140 to 1200 in Ile-de-France, B Beauvoisis, Soissonais, Picardy, Champagne and Normandy, have such small masonry, that it is not surprising; for these edifices are already vast, complex in structure and yet very light. To use cut rubble in such structures as the principal material was great boldness; to succeed was the work of very skilful men. If we examine with care the masonry of the parts belonging to the 12 th century on the cathedrals of Noyon, Senlis, and of a great number of churches of Oise, Seine, Seine-et-Oise, Seine-et-Marne, Marne, Seine-Inferieure, etc., we are surprised that the constructors should have dared to build monuments of very great height and very light with materials appearing so weak; yet the stability of these edifices has long been assured, and if some of them have suffered visible changes, this nearly always refers to particular accidents, such as fire, lack of maintenance, or of loads added later. Of all these monuments, one of the most perfect and best preserved is the cathedral of Noyon, built 1150 to 1190. Except the little columns, the great capitals, the imposts and some exceptional pieces, the entire structure is really composed only of rubble of small resistance.

An idea of this construction will be received from our Fig. 31, that gives a part of the internal twin bays of the nave. The little detached columns of the gallery in the second story, those of the little upper triforium and those separating the high windows, are monolithic and of hard stone set on end. As for the small triple columns A, that before the reconstruction of the vaults in the 13 th century received the transverse arch of the intersection of the diagonal and side arches, they are composed of great blocks set on edge, retained by T cramps at certain distances. But these little columns were set after the structure had settled, and since they are only a decoration and support nothing, the course of the capitals and the imposts whose ends engage in the masonry suffice to support the voussoirs of this transverse arch. We have indicated at B the springing of the old diagonal arches of the great vaults, and at C the side arch behind the diagonal arches. One will note that here as in most churches built at that epoch in the provinces adjoining Ile-de-France, notably in Beau-



Beauvoisais, the piers that support the imposts of the diagonal and transverse arches are much stronger than those supporting only the intermediate transverse arch. In other terms, (see plan), the piers D consist of a cluster of columns, while the intermediate piers E are only cylindrical columns in the ground story surmounted by the cluster - of little columns. The extreme lightness of such construction, the facility for cutting, raising and setting all the materials composing it, explains how, even with weak resources, men could think of building edifices of great extent and very much elevated from the ground. Today that we have adopted the custom of employing enormous masses of great blocks of stone in our least important edifices, of using forces ten times as strong as necessary, we would not dare to undertake to build a cathedral of the dimensions of that of Noyon with materials apparently so weak, and we should spend fabulous sums to execute what one could do in the 12 th century with comparatively minimum resources. We find these structures expensive, because we are not willing to employ the procedures then in use. Yet the cathedral of Noyon is standing after seven centuries, and for a little proper maintenance it can endure still for five hundred years; now twelve hundred years seem to us to be a reasonable duration for an edifice, the great social revolutions to which humanity is subject taking care to destroy them, if they are built to last longer.

Besides the advantages of economy, of facility in providing materials and of execution, constructions of small materials further perfectly suited the system adopted by the architects of the 12 th century. Those light structures producing in plan on the ground an area of solids of small extent with regard to that of the voids, subject to oblique pressures and the laws of equilibrium replacing the Roman laws of inert stability, required in all the members composing them a certain elasticity. Where the constructors were less permeated by the new principles then adopted, and sought to reproduce the forms, that the lay artists of the 12 th century had adopted, without accurately knowing the reason for employing materials of great dimensions, there were produced in the structures such ruptures, that equilibrium was soon destroyed. If the arches were not perfectly independent of each other; if at one point had



been placed materials of high layers, and if beside them this construction was only built of stones of small size, the parts too rigid, too much bonded with the mass, or too heavy, presented a resistance with no result other than to cause ruptures and cracks; the too solid parts of the structure crushed or dragged over the weak parts. Let us again observe, that in the monuments the piers of small horizontal section received the entire load, and that even by reason of the small area of their bearing, they must settle much more than the walls, for example, which supported nothing, since they were even relieved of the weight of the roofs and upper masonry by the side arches. If in this system there is a complete stability of the loaded parts of the fillings, the enclosures and walls, that are not loaded, it is necessary for a rupture to occur. But on the contrary, if constructors have taken care that all loaded parts retain an independent function, they can move and settle freely; if the accessory parts of only enclosures independent of the effects of pressure or thrust, these ruptures cannot occur, and the disconnections favor the duration of the construction instead of being injurious to it.

The Romans only opposed passive resistances to thrusts, but had accepted fully this principle of disconnection, of freedom of parts loaded by vaulted construction and those not so loaded. The great halls of the antique baths are masterpieces in that kind of combination. The entire system consists of piers supporting vaults, the walls are merely enclosures built afterwards, that could be removed without injuring in any wise the stability of the general framework of the structure. These are very natural and simple principles; why not always put them in practice? Gothic constructors carried these principles much farther than the Romans had done, because as we have said many times, they had adopted a system of construction in which every force is active, and where there are no inert resistances acting by their compact mass, as in Roman construction.

The constructors of the 12th century, in erecting their great edifices on plans, where the solids covered little area, and with light materials; in opposing to oblique thrusts active resistances instead of passive obstacles, were not long in perceiving, that it was always necessary to find somewhere this inert stability. If they built flying buttresses against



the surfaces of vaults at the points of their thrusts, these flying buttresses must find an immovable bearing, to effectively fulfil their part; that bearing was the external buttress, a sort of pier erected outside the edifice, on which were resolved all thrusts. To give these buttresses a horizontal section sufficiently large to preserve the immobility of their mass at a great height, was to encumber the exteriors of the edifices by heavy masonry intercepting air and light, and which became very costly. Constructors no longer had the recipe of those Roman mortars, the principal agent of their great structures; that piers that they could have built would not have had the necessary cohesion. It was then necessary to find the means of substituting for the passive resistance of the Roman points of support, a force equally powerful but derived from a different principle. This means was to load the points of support destined to resist the thrusts until they had attained sufficient weight to resist the action of those thrusts. It is not necessary to be a constructor to know that a prismatic or cylindrical pier, composed of superposed courses and with a height more than 12 times its diameter, cannot be maintained standing, if it is not loaded on its top. That law of statics being well known, the Gothic architects believed that they had found the means of erecting edifices, whose points of support might be slender, on condition of loading them with a weight capable of rendering them sufficiently rigid to resist oblique and opposing thrusts.

Indeed, assume a pier A B (32) subject to two oblique thrusts C D, E F, opposed and acting at different heights; the greater thrust C D being = 10 and E F = 4. If we load the top B of the pier with a weight = 12, not only is the thrust C D neutralized, but for a stronger reason also E F, and the pier will remain vertical. Not being able to load the piers of naves with a weight sufficiently great to neutralize the thrusts of the great vaults, the constructors resolved to oppose to the thrust C D a flying buttress G. Hence the weight B O increased by the pressure C D becoming = 15, for example, the thrust E F is neutralized. If the flying buttress G opposes this oblique thrust C D by an equal resistance, and completely neutralizes it, the thrust C D becomes a vertical action on the pier A B, and there is only the need to support the



oblique action of the flying buttress on the external buttress. Now if that external force itself = 8, it is not increased by the total amount of the thrust C D, but only by a small part of that thrust, it is 10 or perhaps 12 in certain cases. The external buttress H already opposing by its own mass a resistance = 8, it will suffice to load it by the weight K = 5, to maintain the general equilibrium of the structure.

We shall refrain from solving these questions of equilibrium by algebraic formulas, that practice continually modifies, because of the nature of the materials employed, their height of courses, quality of mortar, resistance of the ground, the action of external forces, the more or less care taken in the construction. Formulas are good for showing the knowledge of their maker; they are almost useless to the practitioner; he allows himself to be directed by his instinct, experience, observation and that feeling innate in every constructor, that indicates to him what is necessary to do in each particular case. We do not hope to make constructors of those to whom nature has refused that quality, but to develop the instincts of those possessing it. Good sense and reason are not taught, but one may learn to use the one and listen to the other.

The study of Gothic construction is useful, because it has not adopted those absolute formulas, always neglected in the execution by the practitioner, whose least danger is to cause error to be accorded the confidence, that alone should be inspired by facts.

If Gothic construction be not subject to absolute formulas, it is the slave of certain principles. All its efforts and its perfecting tend to convert these principles into laws, and it obtains as a result equilibrium; compressile forces opposed to forces of tension; stability obtained by loads reducing the various oblique forces to vertical loads; as a result is the reduction of the horizontal sections of the points of support; such are the principles, and these are still those of true modern construction; we do not speak of that blindly seeking to reproduce edifices erected in conditions foreign to our civilization and our needs; but of the construction required by our modern needs, or state of society. If Gothic constructors had had at their command cast iron in large masses, they would have enthusiastically taken possession of this



means of obtaining points of support as slender and as rigid as possible, and perhaps they would have employed it with more skill than we do. All their efforts tend to equilibrate forces, and to only regard points of support farther as posts maintained vertical, not by their own sections, but by the complete neutralization of all oblique forces acting on them. Do we act differently in our private structures, in our great establishments of public utility, where the requirements are so imperious, that they silence the routine of instruction? And if a fact should surprise us, is it not to see today in the same city the erection of houses, markets, railway stations, warehouses, supported on columns and covering large areas, leaving to the solids a section scarcely appreciable, and at the same time edifices in which stone accumulates in profusion blocks piled on blocks for covering relatively small areas, only supporting floors exerting no oblique pressure? Do not these facts indicate, that architecture is out of the path traced for it by our needs and our modern engineering? That it seeks to protest vainly against these needs and this engineering? That the time is not distant when the public, oppressed by an art that claims to free itself from its tendencies under the pretext of maintaining classical traditions, for which it cares little, will class the architect among archaeologists, good for enriching our museums and libraries with their learned compilations, and to amuse some assemblies with their sterile discussions? Now we repeat, that Gothic construction, in spite of its defects, errors, and research, and perhaps because of all that, is an eminently useful study; it is the surest initiation into this modern art, which does not exist and seeks its way, because it establishes the true principles to which we must again submit ourselves today, because it broke with antique traditions and is fertile in application. It is of little importance that a turret is covered by ornaments not in the taste of a certain school, if this turret has a reason for existence, if its function be necessary, if it allows us to occupy less space on the public way. It is of little importance that the pointed arch shocks the eyes of the exclusive partisans of antiquity, if this arch be more stable and more resistant than the round arch, and saves us a considerable volume of stone. It imports little that a column has



twenty or thirty diameters in height, if this column serves to carry our vault or floor. In an art entirely of convention and reasoning, the beautiful is not eternally fixed to a single form; it can always be where the form is only the expression of the need fulfilled, of the judicious use of the given material. Because the multitude sees in Gothic architecture only its ornament, and that ornament is no longer of our time, is this a proof that the construction of those edifices cannot find its applications? It would be just as well to assert that a treatise on geometry would be worthless because printed in Gothic characters, and that students reading in that book, "that angles opposed at the vertex are equal to each other," only learn nonsense and are misled. Now if we could teach geometry with books printed yesterday, and could do the same for construction, it is necessary to seek the principles where they are traced in the monuments, and this book of stone, however strange its types or its style, is worth indeed as much as another in reality, as well as for the thought that dictated it.

In no other architecture do we find those ingenious and practical means of solving the numerous difficulties, that surround the constructor living in the midst of a society, whose needs are excessively complex. Gothic construction is not like antique construction entirely in one piece, absolute in its means; it is flexible, free and searching like the modern spirit; its principles allow the application of all materials furnished by nature or industry, according to their proper qualities; it is never stopped by a difficulty and is ingenious; this word says everything. Gothic constructors are subtle, ardent and indefatigable workers, reasoners, full of resources, never stopping, free in their procedures, desiring to possess novelties, all qualities or defects that place them at the head of modern civilization. Those constructors are no longer monks subject to rule or tradition; they are laymen that analyze everything, and recognize no law but reasoning. Their faculty of reasoning scarcely stops before natural laws, and if they are compelled to accept these, it is to conquer them by opposing them to each other. If that is a defect, is it fitting for us to reproach them with it?

We shall indeed be pardoned for this digression; it is nec-



necessary to make understood the sense of the constructions of which we shall present numerous examples. Knowing the tendencies, the independent minds of Gothic constructors, their patient labors in the midst of a society scarcely commencing to be formed, our readers will better appreciate their efforts, and the feeling that produced them. Perhaps like us, they will find in those bold innovators, bold modern engineering, distracted but not suffocated by routine and prejudices of the spirit of the system, by exclusive doctrines.

In commencing this Article, we have seen that if Roman construction is in all parts excellent, wise and coordinated, I like the social constitution of that people, once discovered it marched safely in the same path, invariably following the same laws and employing the same means of execution until the end of the late empire. That was good, admirable, but it could not be transformed. The principal force of the Roman people was to preserve its social constitution in spite of the most evident symptoms of dissolution. Its architecture proceeded similarly; one sees under the last pagan emperors that the execution degenerates as well as taste; but the construction remains the same, the Roman edifice is always Roman. Except the spherical vault on pendentives which belongs to Byzantium, when the Roman empire nears its end, there is no progress, no transformation nor effort. The Romans built as bees make their cells; that is marvellous; but the hives of today are filled just like the hives of the time of Noah. Give to the architects of the baths of Titus cast iron, wrought iron, sheet iron, wood and glass, and require them to make a hall, and they would say to us that they could construct nothing with these materials. modern engineering is different; require it to erect a hall of 66 ft. span with pasteboard, and it would not tell you, that the thing is impossible; it would experiment and invent means to give rigidity to pasteboard, and we can be assured that it would erect the hall.

The Roman traces the plan of his edifice with great judgment; he takes the foundations necessary and proceeds with assurance; no anxiety during the execution; he is certain of the result foreseen in advance, as he has taken all required precautions, and he raises his structure with security, nothing being able to oppose his projects; he has known how to avoid all contin-



contingencies, and sleeps tranquilly while his edifice rises on its immovable foundations. What is further lacking to him? Place? He takes it. Materials? He finds them everywhere; if nature refuses them, he makes them. Men, transportation, money? He is master of the world. The Roman is a superhuman being; he has something of the measured greatness assigned to the Deity; nothing can restrict his power. He builds as he wishes, at the place he chooses, by the aid of men blindly subject to him. Why should he create at pleasure difficulties for himself? Why invent machines adapted to raise the waters of rivers to a great height, since he can seek their sources in the mountains and bring them into the city by a natural slope across vast plains? Why struggle against the regular order of things of this world, since this world, men and things are his?

The error of the first times of the middle ages was to believe, that in the state of anarchy into which society had fallen, one could do again what the Romans had done. Thus while that epoch of transition followed the traces of Roman traditions, what lack of power and poverty! But there soon arose the spirit of modern society, to this vain desire to revive a dead civilization succeeds antagonism between men, a struggle against the material. Society is subdivided, the individual is responsible, all authority is contested, because all powers neutralize each other, combat and are victorious in turn. Men discuss, seek and hope. Among the remains of antiquity, it is not the arts that are exhumed, but philosophy and the knowledge of things. Already in the 12<sup>th</sup> century, to Greek philosophers the select minds went to seek their arms. Then this society, still so imperfect and miserable, is in the true path; its instincts serve it well; it takes from the remains of the past what can enlighten it and make it advance forward. The clergy vainly struggled against these tendencies; in spite of all the power at the disposal of clerical feudalism, it was itself carried away by the movement; it daily saw born around it the spirit of examination, discussion and criticism. Besides at that epoch, everything to weaken one power is supported by a rival power. The national genius skilfully profits by this rivalry; it forms and emboldens itself; always materially dominated, it makes itself morally independent,

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pursues its own course through the struggles of all these powers, still too little enlightened to require from the intelligent multitude that arises, anything but material submission. Many others before us have said with more authority, that the political history of great powers, such as formerly was made, presents but a narrow side of the history of nations; illustrious authors in our time have shown, that one cannot know the life of the people, their developments, the causes of their transformation and of their progress, only by seeking in their own bosoms. But what has not yet been made is the history of those live, active and intelligent persons, strangers to politics, war and traffic; who about the middle of the middle ages assumed such a great part in the country; of those artists or artisans, if one prefers, formed into guilds; obtaining privileges extended by the need of the services rendered by them; laboring in silence, no longer beneath the vaults of cloisters but in the workshops; selling their material labor, but retaining their independent and inventive genius; keeping closely united and marching together toward progress, in the midst of society that used their intelligence and their hands, without understanding the liberal spirit that animated them.

Let others understand a task merely traced here by us; it is fine and made to arouse sympathy; it embraces questions of the highest order; it will perhaps illuminate certain problems set in our days, and that occupy not without cause clear-sighted minds. To know well the past, we believe is the best means of preparing for the future, and of all classes of society, that whose ideas, tendencies and tastes vary least, is certainly the working class, that produces. In France this class demands something more than its daily bread; it requires the satisfaction of its self-love; it demands the preservation of its individuality; it desires difficulties to be solved, for its intelligence is still more active than its hands. If necessary to occupy it materially, it is also necessary to occupy it morally; it desires to understand what it does, why it does so, and that men are grateful to it for what it has done. All admit that this spirit prevails among our soldiers and ensures their success; they why not recognize that it is in our artisans? To speak only of buildings, workmanship has dec-



declined among us during epochs in which men have claimed to subject individual labor to some classical rules established by an absolute power. Now when workmanship declines, social crises are scarcely to be expected in France. Of all industries, that of building certainly occupies the greatest number of men, and demands from each a very high degree of intelligence. Masons, stonecutters, lime-burners, carpenters, joiners, iron smiths, roofers, painters, sculptors, cabinet-makers, upholsterers, and the subdivisions of these various trades form an innumerable army of workmen and artisans, acting under a single direction, very much disposed to submit to it and even to aid it when enlightened, but soon without discipline when that direction is opposed to its own genius. Our workmen and artisans only listen to and follow those, who can tell where they are going and what they want. Why is always in their mouths or in their eyes! there is no need for remaining long in the midst of workmen on buildings to learn with what sarcastic indifference they work on things, whose reason for existence they do not understand, and with what attention they execute works whose public utility they see. A stonecutter does not dress with the same care the block of stone, that he knows will be concealed in a mass, such as he will devote to cutting a stone to be seen, whose useful function is known to him. Every request of the master of the work can effect nothing against this feeling. It is perhaps an evil, but it is a fact easily proved in the work-yards. Appearance is the common weakness in France; not being able to conquer it, it must be utilized. Some desire us to be Latins, perhaps by language; we are nowise so in manners and tastes, character and genius, no more today than in the 12 th century. Cooperation in a common work is active, devoted and intelligent in France, when one knows that this cooperation, however will consequently appear to be appreciated. it is weak, idle and careless, when it is supposed to be lost in the general mass. We beg our readers to become permeated with this natural spirit, too long disregarded, in order to better understand the sense of the examples, that we shall successively place before their eyes.

To become familiar with an art whose resources and practical means have been forgotten, it is first necessary to enter into the spirit and intimate feelings of those to whom that



art belongs. Then all is naturally deduced, all belongs together and the aim clearly appears. Further we do not pretend to conceal any of the faults of the systems presented; this is not a plea in favor of Gothic construction that we make, it is a simple statement of the principles and their consequences. If we are well understood, there is not an intelligent architect, that after having read our work with some care will not recognize the uselessness, to say no more, of imitations of Gothic art, but who will not also understand the benefit he can derive from the serious study of that art, the innumerable resources offered by that study, so intimately connected with our genius.

We shall continue the examination of the great religious structures, first because they are the most important, then because they rapidly develop at the end of the 12 th century, and because the principles by which those edifices arise are applicable to all other construction. We now know the successive phases by which the construction of vaulted edifices must have passed from the Roman to the Gothic system; in other words, from the system of passive resistances to the system of active resistances. From 1150 to 1200 were built in the royal domain, in Beauvoisis and Champagne, the great churches of Notre Dame of Paris, Mantes, Senlis, Noyon, S. Remy of Rheims (choir), Sens and Notre Dame of Chalons-sur-Marne, all after the new principles adopted by the lay school of that epoch, all having retained perfect stability in their principal works.

#### VOUTES. Vaults.

In all things experience and practice precedes theory, the fact precedes the law; but when the law is known, it serves to explain the fact. One observes that all bodies have weight and that a force attracts them toward the centre of the globe. Men still knew nothing of the weight of the atmosphere, of the force of attraction, of the form of the earth; they only knew that every heavy body, if left to itself, was attracted vertically toward the ground. From the observation of the fact are deduced precepts, whether the principles are true or false, that changes nothing in the nature of the fact nor in its recognized effects. The constructors of the 12 th century had not defined the laws to which are subject the voussoirs of t



an arch, viz:-- their weight and the reactions of the adjoining voussoirs. We know by theory, that if one seeks on each bed the point of the passage of the resultant of the pressures exerted there, and that if one passes a line through all these points, a curve is determined, called the curve of pressure. We also discover by the aid of algebraic calculations, that if the equilibrium of the voussoirs of an arch is to be perfect, it is necessary that this curve of pressure, whose first element at the keystone is horizontal if the arch be semicircular, must not pass outside the lines of the intrados and extrados of that arch. This curve of pressure extended below that arch, when it is supported on piers, determines what is called the thrust, then the more the arch approaches in elevation the horizontal line, the more the thrust differs from a vertical; the more the arch varies from the horizontal line, the more the thrust approaches the vertical. Gothic constructors only had the instinct for that theory. Perhaps they possessed some of those mechanical formulas, that one still finds indicated in the Renaissance authors, who have treated of these matters, and which they do not give as discoveries of their time, but on the contrary as traditions proper to follow. For example, relating to the thrusts of arches, men still employed in the 16<sup>th</sup> century a very simple geometrical method for estimating the strength to be given to abutments.

Here (32 bis) is that method; let an arch have the diameter A B, according to the nature of that arch what should be the thickness of the piers capable of resisting its thrust? We divide the semicircular or pointed arch into three equal parts A D C B; from the point B as centre describe a circular arc with radius B C. We prolong a line through the points C and D; its intersection E with the arc described from B as centre, will give the external face of the pier with a thickness equal to G H. If we proceed in the same manner for pointed arches, always dividing them into three equal parts, we shall obtain thinner piers, the more acute are these arches, as our figures show. It is understood that this procedure is applicable only when the arches are placed on abutments of equal heights for these different arches, and which are not more than 1.5 times the diameter or span of these arches. It is probable that primitive Gothic architects had very simple rules for ordinary

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cases; but it is certain that they resorted to their judgment alone always, when they had to solve some new difficulty. As if they had determined the laws of pressure of arches, they arranged to concentrate on the course of these lines the pressure of resistant materials, and thus conducting the thrusts from the summit of vaults to the ground, they successively came to regard everything outside as useless and suppressed it.

We desire to be understood by all; we do not therefore restrict ourselves to definitions. Let  $A B$  be the curve of pressure of the voussoirs,  $B C$  being the thrust; if the wall supports a tunnel vault at the height  $F D$ , its thickness must be  $C D$ . The entire oblique thrust of the vault acting at the point  $C$ , what is the use of the structural triangle  $E D F$ ? Now assume that we have a Gothic pointed cross vault (34); the resultant of the three oblique pressures  $B A$ ,  $C A$  and  $D A$  in plan combines in the line  $A E$ ; in a line  $G H$  in the section. The feeling of the constructor indicating to him the principle, he will make all his masonry construction discharge; i.e., receding from the vertical support  $I O$ , he will set a capital  $M$ , whose projection will meet the direction of the thrust  $G H$ . At  $O$  he will also have a corbel and at  $I$  a discharging capital, so as to bring as nearly as possible the axis  $P$  of the lower column to the point  $H$ , the point reached by the thrust  $G H$ . But being forced in edifices with three aisles to leave this point  $H$  outside the axis of the column, he only regards that as a point of support necessary to maintain vertical equilibrium. He therefore neutralizes all lateral force by constructing the flying buttress  $K$ . But one will object, why retain discharging masonry from the moment that the thrust of the great vault is neutralized by the pressure of the flying buttress? There appears the acuteness of the constructor. That thrust  $G H$  is neutralized but still exists; it is an opposed force, not supported. The flying buttress prevents the effects of the thrust; this is its sole function; it does not destroy the oblique force. Do not forget that there exists a lower vault  $L$ , whose thrust can only affect the column  $P$ , and that this thrust can only be suppressed by the vertical load exerted by the construction from  $R$  to  $S$ , that this vertical load will have the more force when it is increased by the thrust of the great vault, and that the intersection of these two

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 ... in the line A C; is a line B C in the section.  
 ... of the construction relating to him the princio-  
 ... will make all his masonry construction discharge; i.e.,  
 ... from the vertical support B C, he will see a central  
 ... thrust will meet the direction of the thrust B C  
 ... thrust will meet the direction of the thrust B C  
 ... to be as nearly as possible the axis B C of the I  
 ... to the point H, the point raised by the thrust  
 ... thrust forced in edifices with these sides to leave  
 ... outside the axis of the column, he only retains  
 ... of support necessary to maintain verticality by  
 ... He therefore neutralizes all lateral force by con-  
 ... thrust, and the thrust will be null, and the  
 ... thrust assembly from the moment that the thrust of  
 ... thrust is neutralized by the pressure of the living  
 ... There appears the soundness of the constructor. The  
 ... H is neutralized but still exists; it is an opposed  
 ... the thrust; this is its sole function; it does not destroy  
 ... force. Do not forget that there exists a lower  
 ... thrust can only affect the column B, and that  
 ... thrust can only be opposed by the vertical load exer-  
 ... by the construction from B to C, that this vertical load  
 ... have the more force when it is increased by the thrust  
 ... the great vault, and that the intersection of these two

vertical and oblique forces at S, a single point of the capital, it will precisely come to abut the thrust exerted by L S. To determine these forces by calculation would be merely lost labor, for these calculations must vary infinitely by reason of the heights or voids, the thickness of the solids, the quality of the materials, their resistance, the heights of courses, etc. But always human instinct, when it is sharpened, is more subtle than calculation; just as no machine, however perfect, attains the delicacy of the hand and the certainty of the eye. In this case the feeling of the first Gothic constructors served them well; for all naves elevated on cylindrical columns, arranged as indicated in our section (Fig. 34), are rarely deformed in a sensible manner; while most of those whose piers are composed of groups of little engaged columns and rise from the ground, are bent more or less because of the thrust of the lower vaults. But we shall have occasion to return to this later.

This first point explained, we now come to the details of the execution; that is essential. Gothic construction proceeds (if it be permitted to employ this comparison) from an organic system much more complex than that of Roman construction. "So much worse," say some, "that is a mark of inferiority." "So much the better," say others, "that is a proof of progress." progress or decadence, this is a fact that we must recognize and study. Already our Fig. 34 shows that the combination by means of which the thrusts of vaults are resisted in Gothic construction are nothing less than simple. Now all construction proceeding from a complex principle involves a series of consequences, that cannot be simple. Nothing is imperatively logical like a building erected by men reasoning on what they are doing; we shall soon recognize this. The choir of S. Remi of Rheims was rebuilt about 1160, at the time when was erected that of the cathedral of Paris. This structure, very skillfully conceived in its entirety, shows in its details only a series of experiments; which indicates a school already advanced theoretically, but very little experienced in construction. The principles of balance and of equilibrium, that we have traced above, are applied here with rigor; but evidently workmen and foremen were lacking to those first Gothic architects; they had neither had time nor means for training skilful work-



workmen; they were not understood. At most, the choir of S. Remy of Rheims must with reason arouse the admiration of the constructors of the end of the 12 th century, for the methods adopted there are followed in Champagne at that epoch, notably in the rebuilding of the choir of church of Notre Dame of Chalons-sur-Marne.

But let us first briefly trace the history of that charming edifice. The church of chalons-sur-marne was built during the first years of the 12 th century; it was then composed of a nave with side aisles, the nave was probably covered by carpentry resting on transverse arches, like many churches of that epoch and of Champagne, the side aisles were vaulted by means of transverse arches separating Roman cross vaults. The choir was composed of an apse without side aisles and with two square chapels opening into the transepts beneath two towers, like the cathedral of the same city. About the end of the 12 th century (although this monument was erected under excellent conditions, and nothing causes the supposition that it had suffered), these arrangements were no longer in harmony with the ideas of the time; vaulted naves were then desired, side aisles and radiating chapels around the sanctuary. This church was then subjected to a complete rebuilding: the circular wall of the apse was replaced by detached columns; a side aisle was erected giving entrance to these chapels or little circular apses, they retained the two towers flanking the apse, but removed the rear wall and the square chapels arranged beneath these towers, and these served for communication with the side aisle of the chevet. The nave was raised and completely vaulted; instead of the Roman vaults of the side aisles were built cross vaults. Some capitals coming from the demolitions were replaced, notably in the side aisle of the apse. This historical summary shows how men were then disposed to profit by all resources presented by the new system of architecture, scarcely yet sketched. The construction of the apse of the church of Notre Dame of Chalons-sur-marne is very little later than that of the choir of S. Remy of Rheims, but it is already more skilful; one finds there still many experiments, and still the advance is sensible.

We must here resume preceding matters. We have described the simple cross vault between parallel walls, and we have



indicated the first efforts of architects to construct it and maintain it on its piers. It is necessary for us to return on our steps to examine the varieties of these vaults.

From the 11 th century men had already surrounded the sanctuaries of churches by side aisles with or without radiating chapels. (Art. Architecture Religieuse). This method was foreign to the plan of the primitive basilica, and had caused to the constructors more than one embarrassment. Roman antiquity left nothing like it. The Romans certainly had built porticos on a circular plan; but these porticos (if vaulted) were composed of thick piers supporting an annular vault penetrated by half cylinders forming cross vaults, or a series of radiating tunnel vaults placed on arches or even on jointed platbands, as may yet be seen in the amphitheatre of Nîmes. But the Romans had not had the idea of placing cross vaults on porticos formed of detached cylindrical columns, for that could not accord with their system of inert stability. What the Romans had not done, in that as in many other things, the constructors of the Romanesque epoch attempted. They desired to surround the sanctuaries of their churches by porticos or side aisles concentric with the curve of the apse, and to open these porticos as much as possible by supporting by detached columns the vaults that must cover them. Primitively, as for example in the churches of Auvergne and Poitou, they were satisfied by an annular vault, intersected by arches turned by one column to another. To abut the thrust of these annular vaults toward the interior, they first counted on the loads resting on the columns, then on the circular form of the apse, which opposed great resistance to these thrusts. Thus are vaulted the side aisles of the apses of the church Notre Dame-du-Port at Clermont, Issoire, S. Nectaire, S. Savin near Poitiers, etc. Fig. 35 explains this method without the need of more extended developments. <sup>1</sup>

Note 1.p.67. Side aisle of the choir of Notre-Dame-du-Port at Clermont.

But when during the 12 th century the constructors had introduced the system of cross vaults, they naturally desired to apply it everywhere, and they thought with reason, that it was not possible to retain in the same edifice the method of Roman cross vaults beside the new system. Since it was easy

indicated the first efforts of architects to construct it and maintain it in its original form. It is necessary for us to return to our study of examining the varieties of these vaults.

From the 11th century the old system of vaulting was abandoned in favour of a new one, which was introduced by the architects of the 12th century. This new system was based on the plan of the primitive basilica, and had several advantages over the old one. It was more simple, more economical, and more durable. The Romans certainly had built vaults of this kind, but they were not so perfect as the new ones.

One of the chief advantages of the new system was that it allowed the architects to construct vaults of any shape and size. They were no longer limited to the old system, which was based on the plan of the primitive basilica. This new system was based on the plan of the primitive basilica, and had several advantages over the old one. It was more simple, more economical, and more durable.

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to place on the oblong abacus of the capitals A the imposts B cut so as to receive a simple cross vault, that became just as difficult when the cross vault comprised transverse arches and diagonal arches. That difficulty was not the only one. If we represent a part of the plan of the apse of the church of Notre-Dame-du-Port with its side aisle (36), we see that the intersections of the half cylinders A and B with the annular vault C C' give in horizontal projection the two grain lines E F, G H. Note that the aisle being circular in plan, the opening H F is greater than the opening E G; that if we erect a round arch on H F and another on E G, the latter will have its crown much lower than the former; that the intersection by the half cylinder with diameter E G in the annular vault C C' will trace in horizontal projection the line E' L G', and that consequently it will not be a cross vault but simply the intersection of a small cylinder with a large one. To obtain a cross vault E F G H the constructors then stilted the round arch traced on E G, as indicated by its revolved position I K M, taking a height N M = the rise O P. Thus the abacuses of the four engaged and isolated columns R, S, T, V being on the same level, the two crowns were on the same horizontal line, which determined the rise of the annular vault C C'. The idea of stilting the round arches turned on the detached columns T, V was not a caprice, a barbaric whim, still less an oriental imitation, as sometimes claimed, but the result of a very simple calculation of the constructor.

This first step being taken, let us see how the architects of the 12 th century attempted to proceed farther in placing the cross vault on a circular plan. Do not forget that one of the motives, that had caused the adoption of the cross vault was to free themselves from certain oppressive necessities imposed by the antique cross vault, the need of independence felt by constructors. But independence in construction as in everything is only attained by a series of abortive trials. The architects of the 12 th century strongly felt that their principles were fruitful in application, that they led to surmounting without effort the difficulties of the construction of great edifices; however as always happens, these both so simple and flexible principles, embarrassed them cruelly in direct application; to remain faithful to them they made their



constructions complex, they could not entirely get rid of old traditions, and desiring to harmonize them with their new ideas, they fell into infinite difficulties. Yet far from being discouraged, after each attempt they adhered to these new ideas with the ardor and persistence of convinced men. We shall see them at work in the cathedral of Langres, one of the monuments of France most fertile in construction, and certainly one of the best built. Those antique traditions had a considerable power; Langres is a Roman city in a country covered a few centuries since by numerous Roman edifices nearly intact. Let us reach the fact that especially occupies us, cross vaults turned over the side aisle of the sanctuary. The cylindrical column, that remained so late in even purely Gothic edifices, is employed in the choir of the cathedral of Langres. These columns have the proportions of the Roman Corinthian column, and their capitals are quasi-Roman; but (37) their abacus is already arranged with the view of what it must bear; two of its sides are not parallel and form a wedge to avoid warped surfaces in the intrados of the archivolt A that they support; at the side next the side aisle this abacus forms a broken line to offer a projecting point of support to the transverse arch B. At X we give the horizontal projection of this abacus. Feeling the necessity of disengaging the transverse arches, and leaving a place for starting the diagonal arches, and fearing the action of the thrust of the vaults on the columns, in spite of the circular form of the apse, the architect placed on this abacus a projecting corbel C. As shown by our Fig. the groin arches D spring with difficulty; yet the instinct of the artist decorated the springing so as to disguise its slenderness. There are three voussoirs on each other; the two first E, F have their beds horizontal, the third has the joints normal to the curves of the arches. Then these arches with difficulty are disengaged from the square plan, and even the groin arch must be inserted between the voussoirs of the archivolt of the transverse arches. But the constructor already desired to cover his archivolt by a second arch I, that penetrates the groin arch, for the wall is thick over these archivolt; it supports a spherical vault. It is then only above the groin arch, and when this separates from the voussoirs, that a second arch I could be turned. This is not all; these vaults be-



being radiating, the architect has traced his diagonal arches in horizontal projection as indicated in Fig. 38; the surface K L M N being a trapezoid, and the constructor not yet supposing it possible to trace diagonal arches forming broken lines in horizontal projection, the crown O is nearer the line M N than the line K L. The arch K L having its crown at a higher level than that of the arch M N (for he did not dare to stilt the latter), the line R S is inclined from R to S. Our Fig. 37 will sufficiently make this arrangement understood, and the section (39) explains it still better. Besides a construction of this kind, whether intended or produced by chance, presents advantages; it allows the light received under the side arches of the vaults of the side aisle to plunge into the midst of the sanctuary; it does not lose uselessly the height of the inclined roof A; the inclination of this roof and that of the vault give a place for the gallery B; further, it offers great resistance because it transfers a considerable part of the loads and thrusts to the internal cylinder, which forming a vault does not risk separation by slices and departing from the centre. At Notre-dame-du-Port the abacuses of the capitals (Fig. 36) form parallelograms in plan, so as to offer a sufficiently thick bearing for the walls of the sanctuary; it results from this that the stilted arches on these abacuses present warped surfaces and cones rather than half cylinders. At the cathedral of Langres the abacuses of the capitals are traced in wedge form, as we have stated, so as to preserve for the intradoses of the archivolts curved surfaces, that are exactly parts of cylinders. Thus is avoided a difficulty in stonecutting and warped surfaces disagreeable to the eye, but the abacuses in wedge shape make the capitals ungraceful; seen parallel to the diagonals, they give on the side next to the side aisles an angle projecting more than on the side next to the sanctuary. The architects of the Gothic school soon freed themselves from this embarrassment, and knew how to avoid these difficulties.

Our readers will see at once why we have enlarged on the tracing of the manner of constructing the radiating vaults of the side aisles of apses. One word more before coming to the improvements introduced by the Gothic architects. These at first had adopted two methods to neutralize the thrusts of v

...the radiating, the architect has traced his diagonal across  
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vaults; the first method was that consisting of resisting the effects of these thrusts by a force acting in the opposite sense; the second, termed the preventive method, consisted in destroying these effects at their origin, i.e., by preventing their action. Then they employed one or the other of these methods as needed; sometimes they profited by the efforts of thrusts without allowing them to destroy the general equilibrium, as we have seen in Fig. 34; sometimes neutralized these and reduced them directly to a vertical pressure.

A very simple drawing will cause the application of these two methods to be understood. Let (40) be a vault whose resultant thrust is the line A B, then can we establish a structure as given by our sketch. Assuming the stones C, D to each be a single block, resistant and built into the buttress, this construction will be more stable, than if we had erected a pier E A from the ground to the impost of the vault. In this Fig. we profit by the effect of the thrust A B, and we support according to its direction. The flying buttress G and its mass are there only to prevent the vault from spreading horizontally. Let us note in passing, that the flying buttress does not load the pier X, and that it only presses against the vault at the point where the curve of pressure tends to leave the extrados of the voussoirs. That is the method of restraining the effects of the thrust, but using it as an element of equilibrium. Now (40 bis) let this be the vault, the resultant thrust being the line A B. If instead of a flying buttress we oppose to the thrust a less powerful thrust C D, and we place a load E on the imposts of the two vaults, we shall reduce the oblique thrusts to a vertical load, preventing the effects that do not act. This is what we term the preventive method.

There is then something very subtle in these constructions:-  
 1, that the flying buttress is simply an obstacle opposed, not to the oblique pressures, but to their effects, if the equilibrium may be disturbed; 2, that it allows the constructor to profit by these oblique pressures in his general system, without fearing to see the economy of that arrangement disturbed by the beginning of an action outside the equilibrium. But the entire attention of constructors even by this tends to the perfect stability of the buttresses receiving the thrusts of the flying buttresses, for the equilibrium of the

of reduced them directly to a vertical pressure.

forces of the various parts of the edifice depends on the stability of the external abutments. Still the architects did not desire or often could not give to these abutments a sufficient thickness according to their height; then it was necessary to fix them by artificial means. We have an example of the use of this means in the church of S. Remy of Rheims, more frankly emphasized again in the choir of the church of Notre-Dame of Chalons, to which we return.

We first present (41) the plan of one bay of this apse, at A in the ground story, at B at the height of the vaulted gallery of the second story, at C at the height of the triforium, and at D at the height of the springings of the vaults. On the plan of the ground story is to be seen how the architect spared himself the embarrassment of constructing a pointed vault over a trapezoid. He placed at the entrance of the chapels columns E, that allowed him to trace a vault E F G on a parallelogram. Then the transverse arch E H is similar in height and span to the transverse arch F I, and the line of the crown I H of the triangular compartments is not inclined as at Langres, from the exterior to the interior. From E to K a second transverse arch connects the column E to the pier K, and there remains a triangle K E F easily vaulted, since it is only a portion of an ordinary compartment. The method is the same as at S. Remy of Rheims, but not as well applied. It is seen that these upper plans rest exactly over the ground story, unless there is some overhang, whose necessity we shall at once recognize.

In the construction of the choir of Notre Dame of Chalons, there is an important fact, because indicating the efforts attempted by the master of works to free himself from certain difficulties, that greatly embarrassed his colleagues at the end of the 12th century. It will be observed, that the plan of the sanctuary is polygonal in the interior of a semicircle on the exterior. Thus the lower archivolts L connecting the great great columns of the ground story are turned over the sides of a dodecagon, while the archivolts of the gallery of the second story are on a rectilinear plan at the sanctuary, and a curved plan at the gallery; the external wall of that gallery is likewise built on a semicircular plan, and the triforium (plan C) is on a rectilinear plan inside, and a curved



plan outside. It is the same with the upper windows (plan D). The architect desired to avoid the embarrassment produced by the construction of archivolts or transverse arches on a semicircular plan of quite small radius. He feared the thrusts to the exterior, and retaining the circular plan only on the exterior and bringing it to a dodecagon in the interior, he very skilfully combined the advantages of both systems; i.e., the main lines of the walls and concentric bands, a simple arrangement outside and with great stability joined to a satisfying effect in the sanctuary; for the arches pierced in a wall on a circular plan of small diameter always produce lines very disagreeable to the eye.

We now give (43) the section of this construction up to the vaults on the line M N of the plan. This section shows us at A, according to the method then employed in Ile-de-France and the adjacent provinces, the cylindrical columns marked O in the plan; at B is the archivolt and the omission of the vaults of the side aisle. Important churches of that epoch and province all have a vaulted gallery in the second story. (Arts. Architecture Religieuse, cathedral, Eglise). Here the vault is rampant, like that of the side aisle of the cathedral of Langres, not possibly without a motive. (See plan B, Fig. 41). Indeed the side arch C being wider at the base than the archivolt D carries its crown higher, which allows the opening of great windows suitable to light the choir. The triforium E, occupying a very considerable space between the crown of the archivolts of the gallery of the second story and the sills of the upper windows, permits placing a roof F over that gallery with a sufficient slope, in spite of the inclination of the vault G. Let us examine this section carefully. We see that the abacus of the capital of the pier A receives by corbelling the base of the column H, which supports the rib of the vault; this little column and the two others flanking it and carrying the side arches do not unite with the construction (see plan), but are composed of large pieces of stone set on edge. It is the same with the little columns against the gallery and the engaged column I. Thus the pier at the height of the gallery is a prism composed of courses and surrounded by columns on end like the supports of carpentry, in order to secure stiffness under the loads and upper thrusts. It is the



same for these piers at the height of the triforium E (see plan), the nucleus is set in courses and the little columns surrounding it on three sides are set on end. The larger columns at the head are connected by bands forming rings to the body of the construction, by their base and the capital K beneath the imposts. To maintain this cluster, it was necessary to have recourse to the flying buttress. In the plan of the ground story it is evident (Fig. 41), that the architect desiring to open his chapels as much as possible, had made behind the head pier only a very light partition of stone. He could not build a solid abutment on that partition; so he abutted the vaults of the gallery of the second story by a first flying buttress L (see section), transferring this thrust to the abutment separate from the wall of the gallery. But space was lacking on the exterior, and he did not wish the projection of the buttress to exceed the circular line enclosing the chapels. That abutment was then of little depth and unable to resist the thrust of the great flying buttress. Then instead of placing the springing of the great flying buttress vertically over the surface M, the constructor advanced the springing to O. Thus he obtained a strong abutment from O to P, and if he loaded the haunch of the lower flying buttress I, this was rendered very resistant, first by the extraordinary width given to it, then by the upper load R resting on its abutment. Further, to avoid the effect of the thrusts of the great vault between the junction of the great flying buttress S and the springing of the vaults T, he set the external wall of the triforium E and column V on edge, that perfectly stiffened that space, just like a strong wooden strut. Further, under that impost T, that forms a lintel in the triforium and is a little distant from the exterior, the architect has turned an arch Q, which powerfully shores the entire upper system of the construction,<sup>1</sup> and gives an even greater resistance to the arch L. Understanding the effect of the thrusts of the vaults of the gallery and of the flying buttress L destined to neutralize them, fearing the effect of the thrust of a too wide vault on the internal piers at the height of the gallery of the second story, the architect advanced the pier X to overhang the lower column Y, not having to fear a vertical load at that point, but much rather an oblique force produced from



X to Z. As for the great flying buttress, its voussoirs radiate from the centre of the arch above the column V, as if it did not exist; and beneath the head voussoirs the abacus of the capital forms an angle with three voussoirs as indicated by the detail U; a simple stone affirms a wedge between the abacus and the voussoirs. There one recognizes all the acute observation and even the subtlety of those primitive Gothic constructors. In the entire height of the pier from A to E could occur settlements; because of these settlements, the head S of the great flying buttress might be displaced, and exert such a pressure on the column V as to crush it, or in resisting it would produce a rupture at S', injurious to the preservation of the arch. Placing the column as sketched at U, the sinking of the head of the flying buttress could only cause the abacus to slip slightly under the arch and incline the column V a little outwards. In that position resulting from the settling of the great buttress, that column V would press on the arch and load the pier X obliquely, this would cause no danger, since that pier X is placed to act obliquely; further, the column V presses strongly in the triforium wall supporting it, and consequently on the engaged column I, an important point, for this monolithic column I, independent of the pier against which it stands, being heavily loaded and unable to settle, transfers the principal load on the pier to the external surface A' of the circumference of the lower column, i.e., to the point at which it was necessary to obtain a greater rigidity to prevent the effects of the thrusts of the side aisle. There are calculation and foresight; for one will note that the engaged column I" opposite to I is built in courses like the pier X; it was indeed important that this pier should not have the rigidity of the internal pier, that it could yield to settlement so as not to cause a rupture between O and L, if the great buttress settled, which could not fail to occur.

Note 1.p.79. These arches have since been destroyed and replaced by masonry and wood, when the coverings were restored in the 15 th century. It is time to think of replacing them.

So then in this structure the two systems of resistance, preventive and opposed, explained in our two figs. 40 and 40 bis, are simultaneously employed. All that may be subtle, too



subtle, we grant; but this is not the point, ~~for~~ ~~rudeness~~ barbaric. The constructors of that time sought without ceasing, and routine had not taken hold of them; by seeking they found, they advanced and never said; "we have arrived, let us stop here;" it seems to us a very good instruction to follow. We desire today an architecture of our time, a new architecture; that is a very good wish. but it is necessary to know how one invents a new architecture. This is apparently not by forbidding the study of the art most fertile in resources of every kind, the most flexible and free in the use of material means.

However there presented itself a very serious and entirely novel difficulty, when were required vaults of double side aisles surrounding sanctuaries of great extent. The examples just given all belong to edifices of moderate dimensions, and we see that at S. Remy of Rheims and in the church of Notre Dame of Chalons, for example, the external wall comprises a greater number of supports than the inner one, to avoid excessive openings of arches. In a choir like that of the cathedral of Paris, surrounded by double side aisles, it was necessary to arrange the piers so as to make the openings of the transverse arches nearly equal, to obtain vaults with crowns all attaining the same level. The two outer enclosures must then comprise a greater number of piers than those of the sanctuary. At the cathedral of Paris indeed, we see (44) that the circular part of the sanctuary, built about 1165, rests on 6 piers, while the second enclosure comprises 11 and the third 14. Thanks to that arrangement, the archivolts A B, B C, etc., the transverse arches D E, E F, etc., G N, H I, I P, etc., are nearly placed on equal diameters, and the vaults connecting these arches, to carry the rubble compartments, are only composed of single diagonal arches B E, E C, F I, I E, E H, H D, and no longer of groin arches. In the gallery of the second story, the same system of vaults is employed and repeats the plan of the first enclosure. Fig. XX gives the form of these vaults erected on the triangular horizontal plan. The great buttresses K L M alone maintain the stability of the edifice; they receive the flying buttesse of the great upper vaults and the little flying butteesses of the gallery of the second story, turned from G to D, from P to F, etc. As for the thrusts of the two diagonals B E, C E of the vaults of the g



gallery, they are abutted by two little flying buttresses turned from I to E and from H to E. Thus the thrusts and principal loads are transferred to the great external piers K L M, and the thrusts and secondary loads to the intermediate external piers O R S.<sup>1</sup> In the interior, cylindrical columns in the ground story alone support that vast edifice, erected and tolerably complex in its combinations and sections. It is unnecessary to be very expert in architecture to recognize by merely casting the eyes on Fig. 44, that the evident intention of the master of the work was to occupy with his points of support the least possible space in the interior, that he at the same time held to covering the two side aisles by vaults with crowns all at the same level, so as to be able to place on these vaults the area of a gallery and floors having a regular inclination toward the outer perimeter. Shortly after the construction of this apse however, the constructors brought closer the piers A B C, so as to obtain around the sanctuaries narrower bays than those parallel to the axis, and they stilted the archivolts A B, B C; but we should recognize that there is an amplitude in the arrangement of the inner semicircle of Notre Dame of Paris, an independence of conception that charms us. The vaults are skilfully turned on these piers, whose number increases in each series. It is skilful without effort and research. Let us also state that Gothic vaults alone permitted the use of that method, and that the first architects that applied to their structures, at once knew how to derive from it all possible benefit.

Note 1.p.82. It is understood that we here speak only of the primitive construction of the choir of Notre Dame of Paris, before the construction of the radiating chapels.

In the space of 25 years, architects at the end of the 12th century had then obtained results, that had preoccupied their predecessors during the entire Romanesque period, viz:- to vault wide and high edifices while retaining in the interior only slender points of support. The triumph of construction equilibrated by opposition of thrusts, and by addition of upper loads reducing these thrusts to vertical action, was then complete; there only remained to simply perfect the means of execution. The constructors of the 13th century did this, often with too much audacity and confidence in their



principle of equilibrium, but always with intelligence. It is evident that sagacity was the dominant quality of the apostles of the new school. Their efforts tended always to improve upon preceding work, to push the consequences of the accepted principle even to abuse; so much so that during the 14 th century was a reaction, and constructions of questions of equilibrium solved with the most boldness are those raised during the second half of the 13 th century. We shall have occasion to return to that fact.

If it be desired to state the extreme limit reached by the architects of the end of the 12 th century, in regard to the slenderness of the points of internal support and of stability obtained by means of the equilibrium of opposed forces, it would be necessary to see the sanctuary of the church of S. Leu d'Esserent. Certain parts of this structure were erected about 1190, and are made to excite our astonishment. This sanctuary is composed in the semicircle of four single columns, two great and two small thus arranged. (45). The two columns A are only 1.6 ft. diameter, and those at B are about 2.8 ft. A perspective of two bays of the circular plan resting on the columns A (45 bis) indicates sufficiently to us, after what we have just said, that the constructors then counted only on the equilibrium of the acting and resisting forces to maintain such a mass on such a slender point of support. One sees the column A with 1.6 ft. diameter crowned by an extremely expanded capital, (Art. Chapiteau, Fig. 21), on which rests a strong impost and three little monolithic columns supporting the upper vaults. The impost is corbelled out to receive the pier of the triforium and the wall that closes it. The external flying buttress pushes all that construction from outside to the interior; but being erected on a circular plan, it cannot be forced in, and the more the flying buttress pushes against the head of the pier, the more bearing has the construction. The enormous load received vertically by the column H ensures its stability. The equilibrium cannot be destroyed, and in fact this chevet has suffered no movement.

Yet in Ile-de-France the constructors always knew how to retain a certain moderation and never fell into the extravagances so common among the architects of Champagne and Burgundy. Among the latter these exaggerations were justified to a

of equilibrium, but always with intelligibility. It is  
 indeed that necessity was the dominant quality of the sciences  
 of the day. Their efforts tended always to discover the  
 laws of nature, to find the principles of the universe, to  
 explain the phenomena of the world, to find the laws of  
 equilibrium, and constructions of questions of equilibrium  
 with the most boldness and those raised during the sec-  
 ond half of the 18th century. We shall have occasion to re-  
 turn to this later.

It is to be regretted to state the extreme limit reached by the  
 sciences at the end of the 18th century, in regard to the  
 construction of the course of internal support and of stability  
 against the action of the equilibrium of opposed forces, it is  
 still necessary to see the necessity of the change of 18.  
 A statement. Certain parts of this structure were erected  
 and they are made to exercise an equilibrium. This is  
 shown in the principle of four stable columns,  
 a diagram and the same is shown in the same manner.  
 A body of 100 lbs. diameter, and those at B are about 2.5 lbs.  
 respectively of two days of the circular plan resting on the  
 lower of the two. The equilibrium is not only shown  
 in the diagram, but the equilibrium is shown in the  
 equilibrium of the action and reaction forces to maintain  
 the mass on such a slender point of support. One sees the  
 mass of 100 lbs. diameter, resting on an extremely small  
 point. (Art. Chapiteau, Fig. 21), on which rests a strong  
 column and three little columns on each side of the main  
 column. The mass is supported and is shown in the diagram  
 a diagram and the same is shown in the same manner. The  
 reason names all that construction from outside to the in-  
 terior, but is erected on a circular plan, it cannot be for-  
 gotten, but the action of the flying buttress pushes against the  
 side of the arch, and the action of the flying buttress. The  
 column is not only supported by the action of the flying buttress, but  
 actively. The equilibrium cannot be destroyed, and in fact  
 is maintained by the action of the flying buttress.

Yet in the 18th century the constructors always knew how to  
 build a stable structure and they built the most  
 and the most stable of structures and they  
 found the latter these examinations were justified to a

certain point by the excellent quality of the materials of that province, and the Burgundian architects trusting to the point of view of construction, in making us understand how far the application of the Gothic principle can go, when the material comes to its aid.

The vault was henceforth the generator of all parts of vaulted edifices; determining the place, from the arrangement of points of support, and it is first what we must scrupulously study. For whoever knows well the structure of the Gothic vault, the infinite resources presented by its construction, and all other parts of the masonry are naturally derived from that. Our readers have been able already to acquire some knowledge of the elements of the construction of vaults, it remains to examine its details, varieties and improvements, for we cannot longer make ourselves understood, unless before proceeding farther, the different means for closing Gothic vaults are not completely developed.

Figs. 27, 28, 28 bis and 29 indicate how are traced the lower beds of the imposts of the arches on the abacuses of the capitals, how these lower beds determine the forms of these abacuses and the place of the little columns and points of support. One easily recognizes, that in the first traces of Gothic vaults, the constructors avoided as much as possible causing these arches to intersect each other at their springings; they cut each voussoir on the yard according to the section given for each arch, and they sought to arrange them the best they could on the abacus, by cutting them away at the back to conform their setting to the intersections. Thus for example, having traced on the abacus of the capitals intended to receive a transverse arch, two groin arches and two little columns supporting the side arches, the bed of these different members, they set the voussoirs of each of these arches and the bases of the little columns as shown in Fig. 46, cutting away the tails of these arches, if necessary, as may be seen at A, so as to place them beside each other, and to include them within their impost bed. This naive method did not require for the stonecutter any special sketch of the impost, required a bearing on the abacus sufficiently large not to weaken too much the tails of the voussoirs, and consequently capitals quite enlarged; it also had the inconvenience of produ-



producing imposts without resistance that might crush under the load, and of extending the effects of thrusts too low, or to bring their resultant near the external surface. Having to set these arches, the most natural idea was to give to each one its impost. But in certain cases, the primitive Gothic constructors had been forced however to cause to intersect, the various arches supporting a vault on a single capital, isolated as seen in Fig. 42, and to give them a single impost for all; for on these narrow bearings, it was no longer possible to think of arranging the first voussoirs of these arches as one notches together the pieces of a game of patience; that would have been to make these first voussoirs a combination of wedges without resistance. Besides, it was often necessary for these first voussoirs of arches (if they had to support an upper pier) to form a pier, i.e., should present actual courses with horizontal beds, in order to resist the pressure.

For example (46 bis), let a pier A have to support an upper pier B above a vault C. If the arches of this vault are all independent from their springings and have cut extradosses, if the joints of the first voussoirs are normal to the curves, it is clear that the pier B will not rest on the bearing E F as it should, but on the weak filling G, and that then its stability cannot be assured, that the pressure on the haunches of the first voussoirs will infallibly cause disorder, ruptures and crushing. Yet this method was that employed by the last Romanesque architects, and it frequently had disastrous results. In such a case the first Gothic constructors proceeded differently. Let H be the pier bearing the upper load K; they set as many imposts with horizontal beds as necessary for the verticals L M to find a bearing, and commenced the sections of the voussoirs normal to the curves only when these curves became free from the vertical surfaces L M. Up to a certain height, the arches were composed then in fact of a series of corbelled courses with horizontal beds. These constructors had too much sense to imagine the radial joints I, that could never be set well, and whose beds could not be accurately fitted with mortar; they preferred frankly to adopt the corbellings. These had also an advantage, they partly destroyed the effect of the thrusts. We must not omit to say here, that the front voussoirs or imposts are always set vertically



above the upper square of the bell of the capital, as indicated by the brace B, Fig. 47; as for the square of the base of the little column of the side arch, it is set even with the abacus, so that the shaft of the little column comes vertically over the square of the bell of the capital (See the same Fig. 46).

When it was admitted, that one could place at the springings of vaults a series of imposts of arches, superposed with horizontal geds, architects had no need to occupy themselves in finding a bearing sufficiently large on the abacus of the capital to receive the voussoirs of several arches placed together, but only to see that these arches intersected each other on the smallest bearing possible. Always pursuing their reasonings rigorously, they recognized equally, that the resistance of the arches in the system of vaults recently adopted is according to the height of the voussoirs and not by reason of their area, and that with equal areas of section, a voussoir, for example, (47), set as indicated at A, resisted pressure much better, than a voussoir set according to sketch B. Now about the beginning of the second half of the 12th century, the voussoirs of arches are generally composed in a square section C of 8.7 to 13.0 or 19.7 ins, according to the span of the vault; while toward the end of that century, if these voussoirs of transverse arches still retained that section, those of the diagonal arches (whose diameter is greater, but which do not have to resist the pressure of the flying buttress) lose a part of their width and retain depth, as seen at D. Taking less breadth from E to F, their trace on the impost of the capital occupies less space, requires considerable less enlargement, and accommodates itself better to the intersections; having only the blunt edge at G or a simple round, the skew springing on the abacus no longer presents the awkward and inconvenient surfaces, produced by arches of section C. Gradually the architects even renounced that section C for transverse arches, and adopted sections analogous to H, likewise offering from I to K a great resistance in depth, and from L to M a resistance sufficient horizontally to avoid torsion, already maintained by the compartments of the vaults. Thus each day, or rather after each experiment, the architects came to suppress in the construction of vaults everything not



absolutely indispensable to their stability, that they abandoned the last Romanesque traditions in order to obtain:- 1, greater lightness, 2, facility in setting the imposts, since their imposts must thereafter determine the construction of the piers, and consequently of all lower members of the edifices.

But we are obliged, at the risk of seeming lengthy in our explanations of the system of Gothic vaults, to proceed like the constructors of that time, and to follow without leaving it for an instant, the course of their progress. Since these constructors had adopted the flying buttress, i.e., a resistance opposed at certain points to the thrusts of the vaults, it was indeed necessary to collect these thrusts; and to cause that their resultant should only act just at these isolated points; then it was of the last importance, that these transverse and the diagonal arches should so intersect:- 1, so that the resultant of their thrusts is converted into a single pressure at the point where abuts the head of the flying buttress; 2, that no part of the thrust could act outside or beside that resultant; in brief, that the group of thrusts should be perfectly directed in a single and the same line of pressure at the time of meeting the flying buttress as an obstacle. Vaulted ceilings with imposts placed according to Fig. 46 could not attain this absolute result; their thrusts must be, indeed are diffused, and do not combine exactly in one resultant, whose direction and force can be exactly estimated. But if instead of these first voussours set well or badly beside each other on the abacus of the capitals, occupying a large bearing and without connection together, we assume an impost forming a single course; if we combine the springings of the arches so that they completely intersect, so as to make one impost instead of three, we shall have already made an advance, for the resultant of the different pressures will be produced on a single block of stone, which it must render immovable; but if again not being satisfied with that first result, having grouped our arch springings in as small an area as possible, we regard the imposts as only corbelled courses, that we place several of these courses or impost blocks on each other by cutting their beds horizontal until the development of the curves of each arch allows us to separate their voussours from this loaded mass, then we shall be certain to have at the



base of our vaults a resultant of the pressures acting in a line, of which we cannot exactly estimate the starting point, fore and direction; further, we shall be certain that the head of the flying buttress will rest, not against masonry without connection and strength, but against a rigid structure personifying a homogeneous surface, just as would be the carpentry against which rests the head of a shore. But we have made progress; first we have recognized that vaults with diagonal arches comprising two bays, i.e., on a square plan whose diagonals are cut by an intermediate transverse arch, compel us to give the vaults a very swelled form, which obstructs us in placing the carpentry; for the diagonals of the square being much longer than are one of its sides, these diagonals serving as diameters of the diagonal arches elevate their crowns above the springings to a height equal to this half diameter (Figs. 20, 20 bis, 21), a height that the crowns of our transverse arches cannot attain, unless by making these arches sharply pointed.

About 1230 men then renounced this mode of vaulting on a square plan, and established the diagonal arches of the high nave on a rectangular plan, i.e., each bay has its complete vault. We can then cause the crowns of the diagonal, transverse and side arches, to attain the same level or nearly so. The constructors, desiring to have springings with horizontal beds up to the point at which these arches cease to intersect, observed that the simplest method so that these springings may cause no difficulties in drawing, consists in giving to the diagonal and transverse arches the same radius. Then let a vault be on a rectangular plan (48), the diagonal arch  $A B C$ ; transferring the radius  $A D$  to the base line of the transverse arch  $A E$ , we obtain at  $F$  the centre of one branch of the transverse arch, and we draw the arch  $A G$ , that has the same radius as the arch  $A B C$ ; transferring the distance  $A F$  from  $E$  to  $F'$ , we obtain at  $F'$  the second centre of the transverse arch, and trace the second branch  $E G$ . Thus were traced the arches of the first Gothic vaults on a rectangular plan.<sup>1</sup> Then the curves of the diagonal and transverse arches being the same, their sections are alike, and their imposts present no difficulties in drawing. Let us now see how to trace the imposts. Let (48 bis)- $A B$  be



the directrix of the transverse arch, A C the directrix of the diagonal arches. A is placed on the face of the wall. From this point A, taking on the line A B a length A D = to the depth of the transverse arch, and regarding A D as radius, we draw the semicircle D'D D". We then trace the section of the transverse arch on the horizontal plane. We draw two parallels E F to the directrices A C of the diagonal arches, leaving b between these parallels a distance = the width of the voussoirs of the diagonal arches. These are the horizontal projections of the diagonal arches. Taking the point G of the intersection of the axial lines of the diagonal arches with the semicircle D'D D" as the intrados of the diagonal arches, we trace the section of these diagonal arches on the horizontal plane. We then have the bed of the first impost. In the spaces remaining between the semicircle D'D D" and the diagonal arches at H, we place the little columns intended to support the side arches. The outline of the lower bed of the first impost being obtained, we can (only then) trace the abacus of the capital, either returning it square as indicated by I K L or in star form as indicated by I'K'L'. Beneath these abacuses one can place only one capital and one column M, since our intention is to combine the arches as much as possible in a small group. This capital is a corbel, and corbelled stone relieved by the isolated column, causing three corbels to project from a single astragal. It is necessary for us to revolve about the line N O the transverse arch, and about the line A C the diagonal arch. It is clear that these two arches cease to intersect at the point P on the horizontal plane. From the point P erecting a perpendicular P P' to the line N O, the base of the transverse arch, and a second perpendicular P P" to the line A C, base of the diagonal arch, this first perpendicular P P' will cut the extrados of the revolved transverse arch at the point Q. This point Q then indicates the height at which the transverse arch separates from the diagonal arch; it is the level of the bed of the last springing block. It is necessary to divide the height P Q into a certain number of courses according to the height of the layers. Assuming that three courses suffice, the upper bed of the first impost block will be at R, the second at S and the third at T. At Q the arch separates, and we can trace the first section Q V directed to

the direction of the transverse arch, and the direction of the  
 lateral arches, is as shown on the plan of the arch, Fig. 1.  
 The point A, being on the line A B a length A D = to the  
 half of the transverse arch, and regarding A D as radius, we  
 draw the semicircle D' D D". We then trace the section of the  
 transverse arch on the horizontal plane. We draw two parallels  
 to the horizontal plane A C of the diagonal arches, leaving  
 between them parallel a distance = the width of the trans-  
 verse arch. These are the horizontal arches. Taking the point C of the inter-  
 section of the axial lines of the diagonal arches with the semi-  
 circle D' D D" as the center of the horizontal arch, we draw  
 the section of these diagonal arches on the horizontal  
 plane. We draw the line of the first layer, the line  
 separating between the semicircle D' D D" and the diagonal  
 arches at H, we place the little column intended to support  
 the arches. The outline of the lower part of the first  
 layer being obtained, we can (only then) trace the section of  
 the second layer, which is shown as indicated by T R.  
 In this case as indicated by T R, the second layer arches  
 are not only one central and one column W, since the  
 section is to be drawn the same as the first layer.  
 This column is a capital, a corbelled stone rail-  
 ing, or the isolated column, causing these capitals to project  
 from a single surface. It is necessary for us to draw the  
 line N O the transverse arch, and about the line A C  
 the diagonal arch. It is clear that these two arches cross at  
 the point P on the horizontal plane. From the  
 point P erecting a perpendicular P P' to the line N O, the  
 line N O the transverse arch, and a second perpendicular P P'  
 to the line A C base of the diagonal arch, this first perpen-  
 dicular P P' will cut the section of the second layer  
 at the point E. This point E then indicates the height  
 at which the transverse arch separates from the diagonal arch.  
 It is the level of the top of the first layer. It is  
 necessary to divide the height P P' into a certain number of  
 courses according to the height of the layers. Assuming that  
 we divide the height of the first layer into three  
 parts at R, the second at S and the third at T. At S the arch  
 crosses, and we draw the first section of the second layer

the centre of the arch. From this point the voussoirs with a section traced at U are independent. It will suffice to proceed in the same manner for the diagonal arch in tracing the beds R'S'T', above the base line A C, distances between these being same as for the beds R S T. The diagonal arch being less deep than the transverse arch, there will remain behind its extrados at Q', until the intersection with the extrados of the transverse arch, a small surface of the horizontal bed, that will be very useful to us for beginning to set the rubble filling the compartments of the vaults. This done, we can then give the stonecutter each bed of these springings referred to the horizontal plane, as we have traced at in X, the sections that we give in the arches revolved, the beds R S T, R'S'T'. Then we obtain:- 1, at a the lower bed of the first impost block, already traced as stub of the arches; 2, at b the upper bed of the first impost block, that forms the lower bed of the second; 3, at c the lower bed of the third impost block; 4, at e the upper bed of this third impost block, with its inclined sections marked at d. It is unnecessary to state that those impost blocks, if not all, at least the two first, tails in the wall, whose face is Y Z. Would you place the diagonal arches still closer to the transverse arch? It would suffice in beginning the operation to draw on the horizontal plane the axial lines of the diagonal arches from the point A. Even frequently these axial lines do intersect at the point A. To not uselessly complicate the Fig., we have assumed the arches to be merely blocked out; if they have mouldings, one would not proceed differently on the sketch, but in tracing the profiles, for it is necessary to know on the different horizontal beds of the impost blocks, the oblique cuts made on those profiles, so as to give the stonecutter outlines, that take into account the more or less sensible deformation of the mouldings at each bed.

Note 1.p.90. One will indeed note, that these first vaults are quite flat, compared with those of the middle of the 13th century, and that their transverse arches approach the semicircle. Later these vaults appeared insufficiently stable; the diagonal arches were made more acute, or indeed their springings were stilted, so as to be able to raise the crowns of these transverse arches.



To make intelligible the operation just traced, even to persons not familiar with descriptive geometry, we assume (48 ter) the three springing blocks of the preceding Fig., viewed one over the other and moulded in perspective. At A is seen the first springing block, at B the second, at C the third with its cuts normal to the courses of the arches, at D the voussoirs of the transverse arch, at D' those of the diagonal arches free from the springing blocks, therefore similar as far as to the key.

Still it occurs that the arches of a vault are of very unequal diameters, or that their imposts are at different heights; that can nowise disturb the stonecutter; from the moment that one of the arches separates from the others at the extrados, it has a section normal to its curve and the voussoirs are so set, while beside it other arches may remain engaged up to a certain height, and retain the horizontal beds of the impost blocks. Thus for example, (49) assuming that we have to vault a hall divided by a row of columns, whose plan at one end gives us between pier A and pier B a space much wider than that remaining between pier B and the wall C D. Hence we shall have cross vaults as indicated in our Fig. We revolve down the transverse arch E F, which gives us the pointed arch E G F; we revolve the diagonal arch E I, which gives the slightly pointed arch E H I; also the diagonal arch K L, which gives the semicircle K M L; the transverse arch P N, tracing this arch so that the crown may be a little below the level of the crown of the diagonal arch K L, and that its curve approaches a round arch, to lead the eye without abrupt changes to the level from the great vaults comprised between A and B, to the narrower and lower vaults comprised between pier B and wall C D. It is then useful to raise the springing of this transverse arch P N. It is revolved in P O N. It is the need of avoiding abrupt changes of level in these different arches, which has caused us to slightly raise the crown of the diagonal arch E I above the round arch. Thus one sees from the great transverse arch between piers A and B to the little transverse arch between pier B and the wall, that the crowns R M O H and G of the arches, either transverse or diagonal, are successively lowered by a transition almost insensible to the eye in execution.

It is now necessary to assume the impost of these different



It is now necessary to assume the imposts of these different arches on the capital of pier B; we present (49 bis) the forms of these imposts. At A is the springing of the transverse arch marked E F in the preceding Fig.; at B is the second springing with the two sections of the diagonal arches E I; at C is the third springing, whose upper bed is entirely horizontal; at D is the fourth springing with the sections of the two transverse arches P N, the two diagonal arches K L, and the transverse arch connecting piers A and B. One will note the projections R left on the crowns of the springing blocks behind the free voussoirs, to receive the rubble compartments of the vaults. Then there are; the first springing block bearing the section of an arch; the second with sections of two arches; the third with upper horizontal without sections. the fourth bearing section of five arches.

These methods allow great freedom to constructors, and there is no area, however irregular it may be, that cannot be covered without difficulty. Much more, the system of vaults with diagonal arches permits the vaulting of halls, for example, with windows at very different heights, and of making very rampant vaults. For example, assume a hall (49 ter) whose perimeter has four sides A B C D. It is necessary to have on the side A B a window 32.8 ft. high, and not raise the crowns of the side arches on the sides A B C and A D more than 19.7 ft., and the crown of the side arch at the side C D more than 13.1 ft.; the side C D being 26.3 ft. long; on that side C D we draw a round side arch with springing placed on the floor itself, on the other sides we draw side arches at our pleasure, either pointed or round. Dividing the four lines A B, B C, A D, D C, each into two equal parts, we join the middle points G H, I K, by two lines whose intersection at F gives the horizontal projection of the crown of the diagonal arches. Erecting a vertical F E, we take on this line the height to which should rise the crown L, then we have the circular arcs A L, B L, C L, D L, which are the diagonal arches, whose horizontal projections are A F, B F, C F, D F. On the skeleton of the side and diagonal arches, there is nothing more to do than to build the compartments of the vaults, whose intersections or crowns are represented by the dotted lines M N, O P, Q R, S T, taking into account the depth of the voussoirs of the side and diago-



diagonal arches, and the central key being assumed to be placed. But we shall at once occupy ourselves with these compartments and the manner of setting them. Whatever the form of plan of the surface to be covered, the problem to be solved is always this:— 1, to proceed to divide this area by diagonal arches, so as to present a series of triangles, for with this system of vaults only triangles can be covered; 2, to arrange the diagonal or groin arches so that these arches abut each other at their crowns, and that one or more of those connected cannot press on the others so as to deform them.

Thus to cover a polygonal hall with 5, 6, 7, 8, 10 or 12 sides, or even more, it naturally suffices to connect the angles of the polygon by lines meeting at the centre, as indicated in Fig. 50. These lines are the horizontal projections of the diagonal arches, and the sides of the polygons are the horizontal projections of the side arches, which may have their crowns above or below the level of the central crown, as requirements indicate. If it is necessary to cover a portion of the polygon at the extremity of a parallelogram, or as that is found in the sanctuaries of churches, for example (51), we arrange to have before the part B C a bay A B equal to one of the sides of the polygon B C, so that the crown D may be equidistant from the points B C E, etc., and that the triangles B C D, C E D, may have their sides B D, C D, E D equal, each to each. In this case, the arches A D abut the arches B D, C D, E D, etc., and we always only have to fill the triangles. Yet there are exceptions to this rule, and one sees the radiating arches of apses abut their heads against the crown of a transverse arch (51 bis), when for example the apse is half a polygon of 10 sides; but that method is vicious, because the arches all pushing against the crown D and not abutted, may bend the transverse arch G H. In that case, experienced constructors have turned two half diagonal arches I D', R D', intended to strongly abut the crown D'. But if these vaults can be constructed by means of arches with crowns at different levels, they can also be closed on arches of very different diameters, and whose crowns all lie on one level. It is sometimes necessary to level the crowns, if for example, this concerns vaults supporting a surface above them. This fact frequently presents itself in porches surmounted by galleries or



halls in the second story.

The porch of church Notre Dame of Dijon is one of the best examples that we can select. Its plan (52) continues the plan of the three aisles of the church itself; but the central vault, instead of being raised as in the church, has its crowns at the level of the vaults of the side aisles, for it is necessary in the second story to receive a level passage over the entire area of this porch; desiring to give a base to the facade, the constructor has doubled the piers at this point and has turned parallel transverse arches, separated by a tunnel half vault between A and B, E and G, B' and C, G' and H, E' and F. Then the central part of the porch is covered by a vault with cross arches G K, E I, intersected by a transverse arch L M. The side aisles are covered by cross vaults on a square plan. On our plan we have drawn these revolved arches, whose crowns are placed in the same horizontal plane. The diameters of these arches having very different lengths, it was not possible to have these arches spring from capitals set at the same level. Thus the capitals of the diagonal arches G K, E I, and of the transverse arches E G, L M, G K, are placed lower than those of the arches G M, M I, E L, L K, and of the diagonal arches of the side aisles. If then we give a perspective of the pier M, (53), we shall see that the transverse arch A springs much below the other arches, and that its capital A conforms by the place it occupies, to that difference of levels. The drums of the pier support the two impost blocks C, D of the transverse arch M L (of the plan), which separates below the capitals of the other arches. As for those other arches, their imposts rest on a group of capitals relieved by little Monolithic columns. The effect of the unequal thrusts of these arches acting at different heights is neutralized by the vertical loads supported by the piers, which are considerable.

Already about the middle of the 13th century in England, men arrived at combinations of arches, very sagacious and perfected. The Normans quickly became skilful constructors, and in their edifices of the Romanesque epoch, they had made remarkable efforts by indicating great independence and an exceptional perfection of execution. Already at the beginning of the 12th century, they built cross vaults with projecting r

the main story.

The story of the tower of the church is one of the best  
 examples that we have of the plan (see plan 12) combined with the  
 the other sides of the church itself; but the central part  
 of the tower of being raised as in the church, has its crown  
 the level of the vaults of the side aisles, for it is not  
 only in the second story to receive a level passage over it  
 the entire area of this portion; assisting to give a base to the  
 tower, the construction has been the same at this point  
 and has turned parallel transverse arches, separated by a thin  
 wall, with a half-arch between A and B, B and C, C and D, D and E,  
 and E and F. The central part of the tower is covered by a vault  
 in five arches G, H, I, J, K, L, intersected by a transverse  
 wall. The side aisles are covered by cross vaults on a  
 square plan. On the plan the tower is shown as a square  
 with four corners are placed at the same horizontal plane. The first  
 story of the tower having very different foundations, it was  
 not possible to have these arches spring from capitals set at  
 the same level. The foundations of the tower are shown in plan  
 13, and of the transverse arches G, H, I, J, K, L, and of the  
 longitudinal arches of the side aisles. If then we give a correspond-  
 ing level of the plan (see plan 12), we shall see that the transverse arches  
 spring from below the other arches, and that the capital A  
 is placed by the side of the other arches, so that the difference of level  
 is the same. The tower is shown in plan 13, and the side aisles in plan 14.  
 The transverse arches G, H, I, J, K, L, which are shown in plan 13,  
 are the capitals of the other arches. As for these other arches,  
 their capitals rest on a level of capital different from the  
 longitudinal columns. The effect of the unusual character of  
 the tower and its different capitals is neutralized by a  
 vertical line supported by the piers, which are considered

about the middle of the 13th century in England,  
 arrived at combinations of stones, very sagacious and new.  
 The Normans entirely passed skillful constructors, and  
 their skill of the Romanesque style, they had made some  
 progress by indicating great independence and an exor-  
 cism of execution. Already at the beginning of  
 the 14th century, they built cross vaults with projecting

ribs, when in France were only found Roman cross vaults without diagonal arches, but with surfaces curved in all senses, as we have seen above. They knew the benefit to be derived from the imposts, and they divided their capitals, if not the vertical supports, into as many members as there were arches to be received. Thus in the Romanesque portion of the cathedral of Peterborough, the vaults of the side aisles of the choir opening on the transepts are for that epoch, conceived and erected with more knowledge and precision than those of the royal domain of France, champagne, Burgundy and the Centre. These vaults rest alternately on cylindrical and prismatic piers set at the angles on the axes. The capitals pass from the section of the piers to the lower beds of the different arches by means of corbellings skilfully combined. Fig. 54 presents the horizontal section A B C D E F G H of a pier, the plan I K L M N O P of the abacus of the capital, the trace of the lower bed on this abacus, of the transverse arch Q, of the archivolts supporting the walls of the transept R, of the diagonal arches S, and of the base of the engaged column T, rising to the upper carpentry covering the principal nave. So that the crowns of the diagonal arches of the vaults of the side aisles may not exceed the level of the extradoses of the archivolts and of the round transverse arches, these diagonal arches are traced as a portion of a circle less than a semicircle. Fig. 54 bis shows in perspective this capital and the springings of the arches; at A is seen one branch of the diagonal arch. The geometrical drawing (54 ter) explains the springing of that branch of the diagonal arch A, the imposts of all these arches and the corbellings of the capital.

When one compares this construction with those contemporaneous in France properly so-called, he has reason to be astonished by the knowledge and experience of the Norman architects, who already at the beginning of the 12th century were able to construct cross vaults, and to divide the capitals into as many members as the number of arches to be received. But before following the rapid progress of the Anglo-norman vault, and discovering the singular results attained by the architects beyond the English channel about the middle of the 13th century, it is necessary for us to first examine the means employed by French constructors for closing the triangles of



Gothic vaults. The general principle must precede varieties of execution.

Let (55) be the plan of a cross vault crossed by a transverse arch, according to the method of the first Gothic constructors. A B is the diameter of the principal transverse arch; A G the half diameter of the diagonal arch; A D the side arch; D C the half diameter of the transverse arch dividing in two equal parts the triangle A E C. The side arch must first dominate. Assume the rubble to be easily handled, so that one mason can easily set it by hand, having the width X X' (which varies from 3.2 to 5.9 ins. in this kind of construction). We revolve the extradoses of all these arches into the horizontal plane. These revolved figures give us for the side arch the pointed curve A F D, including its stilted springing; for the principal transverse arch the pointed curve E G, for the diagonal arch the exact quadrant curve A I; for the transverse arch of the intersection the pointed curve D H. Do not forget that the diagonal arch being round, the intersecting transverse arch must have a rise equal to C H and equal to the radius C I; that in ordinary cases the principal transverse arch must have a rise J G shorter than the radius C I, and that the side arch must have, including its stilted springing a rise K F less than that of the principal transverse arch. The width of the bed joints of the rubble of the filling being X X', we find how many times the extrados of the half side arch A F contains X X', including its stilting; let this then be four times; we mark the division points L M N. We have 4 courses of rubble.<sup>1</sup> Replacing the side arch over its horizontal projection A D, the point N on the vertical part of the side arch will fall at N', the point M at M', L at L', and the point F of the crown at K. We then divide the half A I of the extrados into 4 parts, and mark the points O P Q. Replacing this curve over its horizontal projection A G, we obtain on this arch the points O' P' Q' C'. We proceed in the same manner for the intersecting transverse arch D C, whose revolved extrados is D H. We divide this extrados into 4 parts, and mark the points R S T. Revolving the arch on its half diameter D C, we obtain in horizontal projection the points R' S' T' C'. Then joining the point N' with the point O', M' with P', L' with Q', K with C, etc., by straight lines, these straight lines give



the horizontal projections of the vertical planes in which  $m$  must pass the sections of the intrados of the beds of the filling. These obtained, the principal transverse arch determines the number of beds of the vaults closing the triangles  $E E C J$ . The unit division  $X X'$  giving us 6 divisions of courses on the extrados of the principal transverse arch revolved in  $E G$ , we mark the points  $U V Z$  ect., and operating as before, we obtain on the line of horizontal projection  $E J$  of this transverse arch the points  $U'V'Z'$ . Dividing likewise the extrados of the diagonal arch into 6 parts, and projecting these divisions on the line  $E C$  of the plan, we obtain the points  $Y Y'Y''$ , etc. We then connect the point  $U$  with  $Y$ ,  $V'$  and  $Y'$ , etc., and we have the horizontal projection of the vertical planes in which must pass the sections of the intrados of the beds of the filling. This drawing is not made on the yard. After having divided the extrados of the side arches and of the principal transverse arches, which determine, according to the number of beds given by the width of the rubble, one divides in equal numbers the extrados of the diagonal arches as we have just shown, and proceeds at once to the construction of the vaults without centering; this is the method employed, which gives in horizontal projection the lines  $N'O'M'$ ,  $P'L'Q'$ , etc.,  $U'Y$ ,  $V'Y$ , etc., that we have just traced on our drawing.

Note 1.p.103. To not complicate the Fig., we assume a very small number of divisions of beds. The operation is the same, whatever the division of the beds.

Here is what composes that method. For example, the constructor says that the line  $C K$  connecting the crown of the diagonal arches with the crown of the side arches shall have a rise of 1.64 ft.; the mason is accustomed to build this sort of vaults, and has no need to know more to construct without a drawing the entire filling triangle  $A C D$ . It suffices him to take the length  $C K$  or  $C J$ , to lay it off as  $C'K'$  on a plank (56), to erect at the middle of that line a perpendicular  $a b$  of 1.64 ft., and to trace an arc through the three points  $C' b K'$ . With this curve beside him, he builds at least a third of each side of the filling like a wall. It suffices for him to take with a string the length of each curve of rubble, to lay off this length on the arc  $C' b K'$ , and to see that this



cord gives the rise for that portion of the arc thus cut off; this rise is what he must take for the course of the rubble for closing. The first third of the filling so nearly approaches a vertical plane, that the rubble retains itself on the beds, as the mason sets it, as shown in Fig. 57. But beyond or about at the first third, is required the aid of a centre, and the more because the curves of the rubble increase in length as one approaches the crown. Now since these curves elongate, it is necessary to cut a centre for each one, which would be lengthy and expensive. It is then necessary to have two centres arranged as indicated in Fig. 58, when together being longer than the course at crown of the filling, one of them not longer than the curve of rubble too much inclined to be turned without the aid of a support. Each of these curves being cut from a plank of about 1.6 ins. thick, has at the middle an open slot concentric with the curve given by the standard arc mentioned above. (56). By the aid of two pins C passing through these slots, the centre may be made rigid, and at each course it may be extended as needed, by sliding one part on the other. The centre is fixed on the extradoses of the arches by means of two iron angles nailed on the ends of the centres; the mason must take care before placing the points A B on the points marked on the arches, to allow the face of the centre to hang vertically before fixing against the sides of the arches by wedges or a handful of plaster. Thus the workman closes the fillings of the vaults according to the drawing traced in Fig. 55; i.e., by giving each course of the filling a curve sufficient to hold them together and to transfer their weight to the arches, and he is no less obliged to pass this curve in a vertical plane, for he must place the centre under each line separating the courses of rubble, as shown by Fig. 59, and not beneath the middle of these courses of rubble. It is not without reason that he must place the centre in a vertical plane, and consequently keep the bed of each course of rubble in this vertical plane. These beds (60) at the intrados tracing curves, it results that the section C D must have a greater <sup>er</sup> development than the section D B, that determines the number of rows of rubble, and even that of section D A, although in horizontal projection the line D A must be longer than the line D C. The mason must take into account



at each course of rubble, this surplus width, and give to each of these courses an inner surface presenting the surface traced at E. It is then necessary for the workman to be guided by a mechanical means; the centre being always set vertically necessarily establishes the form to be given to the lower surface. If the mason closed the fillings by courses of voussoirs with inner surfaces of uniform width for their entire extent, on arriving at the crown he would take into account the entire surplus of the width given by the section C D over the section D B, and he would have the two last courses of rubble presenting on the intrados a surface like that shown at G, which would be disagreeable in effect, and would compel the use at that point of rubble of much greater width than elsewhere. By the vertical position of the centre being compelled to cause the edge of the intrados to lie in a vertical plane, without knowing it, the mason succeeds in giving each course the surplus width imposed by the concavity of the vault. All that is much more simple to execute than to explain, and we have never found any difficulty in causing this method to be adopted in practice. A skilful mason, aided by a boy who brings him the split rubble and his mortar, closes the triangle of the vault without the aid of any machine, without centering and without tools other than his axe and his centre. Once that the workmen understand the construction of these vaults (which does not take long), he sets the courses of rubble with great facility, having only to dress them slightly with his axe to remove their parallelism. Nearly always when he has acquired the practice, he abandons the slotted centre and contents himself with two curves held together by two spikes, extending them at each course, for the beds of the rubble being very little inclined, except near the crown, a weak support suffices to prevent it from sliding on the mortar. Each course set forming an arch, the centre is removed without the result of the least movement. It must be stated that this rubble is generally thin, and that many fillings of great Gothic vaults, particularly at the end of the 12th century are no more than 4.0 to 4.8 ins. thick.<sup>1</sup> This method of constructing vaults is not the only one; it belongs solely to Ile-de-France, Beauvoisis, and Champagne during the second half of the 12th century; while in the other provinces less reasonable means

and nature of rubble, this surface will, and give to the  
of inner surface an inner surface presenting the surface  
of the wall. It is then necessary for the mason to be guided  
by a mechanical means; the centre being always set vertically  
by constantly establishing the form to be given to the wall  
surface. It is then closed the finished by courses of  
solidity with inner surfaces of uniform width for their  
to extend, and arriving at the centre the wall will have  
the same radius of the width given by the section C  
of the section D, B, and he would have the two last courses  
rubble presented on the section A section B section C  
of the wall. It is then possible in effect, and would consist  
of an outer layer of rubble of small stones, and a  
inner. By the vertical position of the rubble the wall  
is to cause the edge of the rubble to lie in a vertical  
line, without knowing it, the mason suggests in giving each  
course the rubble with imposed by the convexity of the wall.  
All this is much more simple to execute than to explain.  
We have never found any difficulty in causing this method  
to be adopted in practice. A skilled mason, aided by a boy  
to place him the solid rubble and his master, of course the  
quality of the rubble without the aid of any machine, without  
level and without tools other than his eye and his compass  
to judge the position of the rubble and the position of the wall  
is (which does not take long), he sets the courses of rubble  
to great facility, having only to dress them slightly with  
a small remove their parallelism. Nearly always when he is  
working the rubble, he establishes the vertical position of  
the wall itself with two curves held together by two strings,  
forming lines of small curves, for the sake of the rubble  
a very little inclined, except near the crown, a weak support  
is sufficient to prevent it from falling on the mortar. Then  
it is not forming an arch, the rubble is removed without the  
aid of the least movement. It must be secured for this purpose  
is a vertical line, and the rubble is held in place by the  
line, particularly in the case of the rubble which is  
less than 4.0 to 4.5 ins. thick. This method of constructing  
walls is not the same; it requires solidity in the rubble  
and the position of the rubble and the position of the wall  
itself, while in the other provinces less reasonable means

were adopted. In Burgundy, thanks to certain particular qualities of the limestone, splitting into thin layers, rough and adherent to the mortar, men long constructed vaults of plastered masonry on wooden centerings. The vaults of the choir of the abbey church of Vezelay, built about the end of the 12 th century, present a singular mixture of methods adopted by the constructors of Ile-de-France and of Burgundian traditions. One sees how the Burgundian stonecutters, such skilful draftsmen, were embarrassed in giving to the filling courses proper forms; not being able to make the exact drawing, they experimented, built the haunches of materials cut good or bad; then not knowing how to close these fillings, they completed them by rough rubble plastered. That was not a method, but was an expedient.

Note 1.p.108. The fillings of the great vaults of the cathedral of Paris are not over 4.0 ins. thick.

In the midst of the provinces of ancient Aquitaine, the custom that the constructors of the 10 th and 11 th centuries had contracted of closing their vaults by domes was so deeply rooted, that they only very late understood the Gothic cross vault, and which they adopted in appearance, but not the actual structure.

Everyone knows that the voussoirs composing a dome give in horizontal projection a series of concentric circles, as indicated in Fig. 61. A being the section and B the quarter of the horizontal projection of a hemispherical dome. When the system of Gothic construction prevailed in the royal domain, and the architects recognized the use that could be made of it, they soon desired to adopt it in all the western provinces of the continent. But these different provinces, attracted by the frank charm of the facilities presented by the new architecture for conquering obstacles before insurmountable, no however could not abruptly set aside traditions strongly rooted among workmen; there resulted from this<sup>a</sup> sort of compromise between the structure and the form. In the 12 th century were seen to rise along the entire line extending from Perigord to the Loire to Angers and beyond, vaults that by construction are actual domes, but which seek the appearance of cross vaults. These are domes beneath which have been turned two diagonal arches, rather a concession to the taste of the time than



as a requirement of stability; for in fact these diagonal arches are generally very weak and support nothing, frequently being engaged in the filling and supported by it. This observation is of major importance; we shall see at once what the consequences were. Still these builders of domes at any cost were not long without recognizing that the structure of their vaults was not at all in harmony with their apparent form. The movement was impressed over nearly the entire area of present France about the end of the 12 th century; it was necessary to adopt the mode of construction invented by the artists of the North; it was essential to abandon Romanesque traditions; they were exhausted; the people rejected them because no longer sufficing for their needs, and especially because they were the living expression of that monastic power against which rose the national spirit. The schools subjected to the dome made a first concession to the new mode of construction; they understood that the diagonal arches were made in Gothic construction to support the fillings; then instead of setting the courses of rubble for filling as they had done at first, without taking into account the diagonal arches as indicated in Fig. 72, they took the extradoses of these arches as points of support, and turned courses of rubble, not as side or transverse arches on these diagonal arches, like the constructors of Ile-de-France, but as arches diagonal to the side and transverse arches, having them intersect at the crown.

Fig. 63<sup>1</sup> will illustrate this arrangement. This construction was less natural than that of the vault of the North, but it gave the same sections; i.e., that from A, the crown of the side or transverse arches, to B, the triangles of the filling A B C form a reentrant angle, a concave line. But since these junctions A B of the courses of rubble produce a bad effect, and present a difficulty for the mason, who needed on that line A B a wooden curve to support each course of rubble as he set them; a stone rib B F was turned to receive the ends of the courses of rubble and to conceal the joints.

Note 1.p.110. Vaults of the cloister of Fontfroide near Narbonne, side aisles of cathedral of Ely, cloister of Westminster (England), side aisles of church of Eu.

At the end of the 12 th century Aquitaine was Anglo-Norman, as well as Maine and Anjou. This system of vaults not only p



prevailed in these provinces but passed the Channel and was adopted in England. Gradually during the first years of the 13th century it was abandoned in the provinces of the continent, to definitely adopt the mode of Ile-de-France; but in England it persisted and extended, was perfected and soon led the constructors into the system of vaults opposed in principle to the French system. The manner of setting the courses of rubble in the fillings of vaults on arches, borrowed in Ile-de-France from Roman cross vaults, in England from the dome, had singular consequences. In France the surfaces of the fillings always remained concave, while in England they ended by being convex at the intrados, or rather by forming a series of curvilinear cones, reversed the intersecting, producing forms consequently opposed to their origin. But when one studies Gothic architecture, he soon recognizes that reasoning, the logical consequences of an accepted principle, are followed with inflexible rigor, even to produce results apparently very strange, exaggerated, distant from the starting point. For him that never loses the traces of the incessant attempts of constructors, the transitions are not only perceptible, but are deduced by reasoning; the slope is irresistible; they seem the result of caprice, if one ceases for an instant to hold the thread. Thus one should not accuse the bad faith of those, who not being constructors, judge what they see without understanding the origins and the sense; what one can reproach them with is the wish to impose their judgment, and to blame the artists of our time, who believe that they find in this long travail of human genius resources and useful instruction. Each one can express his feeling, when it concerns a work of art, saying; "This pleases me, or that displeases me;" but it is not permitted to anyone to judge the product of reason otherwise than by reasoning. It is free for each one to not admit, that a perpendicular to a straight line forms two right angles; but to wish to prevent us from proving it, and especially to recognize it, is to push the love of obscurity rather far. Gothic architecture may displease by its forms; but if one claims it is only the product of chance and ignorance, we shall demand permission to prove the contrary, and having proved it, to study and use it, if this seems good to us.



Then having to close this section on vaults, let us see how the Anglo-Normans transformed the dome of the West into a vault of a form very different in appearance from the hemispherical vault. We have just stated how the constructors of Aquitaine, Anjou, Maine and England, had been led to add other ribs to the cross vault to conceal the junctions of the rubble filling at the lines of the crowns; i.e., how they divided a square or rectangular vault into eight triangles instead of four. This point of departure has such great importance, that we ask from our readers permission to insist on it.

Assuming a cross vault, half made by Frenchmen at the beginning of the 13<sup>th</sup> century, and half by Anglo-Normans. The French vault will give in horizontal projection (64) the drawing A; the Anglo-Norman vault the drawing B. Hence nothing is more natural than to connect the crown C of the side arch with the crown D of the diagonal arches by a projecting rib masking the junction formed by the meeting of the filling triangles of rubble E C D, F C D. These filling triangles are evidently derived from the dome vault, or rather are four pendentives that intersect in C D. The vaults of Aquitaine or primitive Anglo-Norman vaults further have the crowns of the side arches at a level lower than the crowns of the diagonal arches, and their skeleton is presented in Fig. 65. This Fig. shows well that the Anglo-Norman vault is nothing else than a hemispherical dome intersected by four pointed arches, for the diagonal arches are round. On that skeleton the courses of the fillings in rubble and turned as marked in G, while in France, on two diagonal arches and four side arches of the same dimensions and form, the courses of rubble fillings are turned according to the drawing H. Then although the principal ribs of vaults in France or in England may be identical in drawing, in France the filling is evidently derived from the Roman cross vault, while in England it is derived from the dome. Until then, although the principles of construction of these two vaults are very different, their appearance is the same, save the additions of ribs connecting the crowns of the side or transverse arches with those of the diagonal arches, an addition that is not an absolute rule.

While in Ile-de-France and the adjacent provinces at the end of the 12<sup>th</sup> century, there were rarely built cross vaults c



crossed by transverse arches, i.e., always generated by a square plan and closed by skew filling triangles, as shown by Fig. 55, men sought in the West to obtain the same real and apparent lightness, but always retaining something of the dome.

There exists near Saumur a little church, that indicates in the most evident manner the uncertainties of the constructors of the West between the innovations of the architects of the royal domain and the traditions of Aquitaine; this is the church of Mouliherne, there the two systems are together. The first building of the edifice has a single nave next the facade, and is vaulted according to the plan (66). From A to B is a great transverse pointed arch. From A to C and B to D are two pointed diagonal arches, that are only rounds with semicircular sections. A second transverse arch E F with similar section crosses the two diagonals. From E to G and F to G are turned two other secondary diagonal arches intersecting the principal diagonals at I and K. The four triangles comprised between the points E G F are closed according to the method of Aquitaine or the Anglo-Norman, i.e., according to the principle of the dome; the four other triangles E D I, D G I, G C K, C F K, are closed after the French system, and still the ribs L I, M I, N K, O K, connecting the crowns of the side arches with the intersections I and K, project below the courses of the fillings. These ribs are even decorated by figures carved in relief. As for the triangles A E R, B F R, they are closed in the French manner by skew fillings. But a half transverse arch existing from G to R, the constructor has thought to continue it as a projecting rib as far as the top of the great transverse arch A B. Then the section made on G S gives the drawing (67). If one desires to have an exact idea of the appearance of this vault, it is necessary to refer to the prespective view, that we give (68). In the royal domain,, one would be content to close the triangles of the filling (Fig. 66), E D R, D G R, G C R, C F R, by courses of rubble placed from the side arches E D, D G, etc., to the transverse and diagonal arches E R, G R, D R, absolutely as done for the triangle A E R.

As long as the vault of Aquitaine and the Anglo-Norman retained its very stilted diagonal arches, like those of the primitive French Gothic vault, the appearances of these vaults



were nearly the same; but in France from the end of the 12<sup>th</sup> century was recognized the advantage in raising the crowns of the side and transverse arches to the level of the crowns of the diagonal arches; 1, to be able to have higher windows, 2, to allow the tiebeams of carpentry to pass above the vaults, without raising the side walls too much. It was desired to imitate this improvement in the Anglo-Norman provinces. Then a difficulty presented itself; the principle of construction of the courses of rubble of the filling derived from the dome lent itself badly to that innovation. We have just said that a rib had to be placed beneath the junction of the ends of these courses of rubble. Now assume an Anglo-Norman vault of the section given (69); when it was constructed according to the drawing A, the rib connecting the crowns B C could offer a perfect resistance by its curvature, but if it was constructed according to the drawing D, according to the new French method, the projecting rib C E had not sufficient rise to present sufficient resistance; if the vault was great, it was to be feared, that this rib might bend at G, about the middle of its length. To avoid this danger, the Anglo-Norman constructors did not abandon for that their method of filling; they preferred to support this weak point G by new projecting ribs, traced in H I on the horizontal projection K, and then instead of turning the arches of the filling of rubble as traced at L, then set them as traced at K. Examining the quarter O M P I, of the vault, one recognizes that its internal surface was already near, because of the arrangement of the courses of rubble filling, to giving a portion of the curvilinear concave cone. Once on that path, Anglo-Norman constructors no longer thought of the French vault, they freely developed the principle, that they had perhaps unconsciously adopted at the origin; they saw in the Gothic vault only a net of interesting arches reciprocally staying each other, and supporting the fillings only giving each of these surfaces scarcely concave. Already at the middle of the 13<sup>th</sup> century, they erected the choir of the cathedral of Ely, whose high vaults give the horizontal projection (70) and the section D made on C'D'. Confiding in the strength of these crossed and counter stayed arches, they did not hesitate to raise the crowns C'D' of the side arches E F above the crowns



G, so as to have very high windows, as indicated by the section C D. But the appearance of these vaults in the interior is quite different from that of the French vaults. Here is a perspective view of one springing of the vaults of the choir of the cathedral of Ely (71). It is seen that these arches or projecting ribs give a group of curves, a considerable portion of which presents a conical curvilinear concave surface, and to render this effect more striking, the constructor has taken care to combine all the arches on the abacus of the capital into a compact group, whose lower bed we indicate (74 bis) at A, and the horizontal section at the level B, at C. But if this horizontal section traces a portion of a polygon resting on the branches from D to E; from D to F, which is the side arch, it returns abruptly, for the springing of the side arch being made <sup>much</sup> higher than that of the diagonal, transverse and intermediate arches, the rubble filling G F must rise vertically in a plane passing through G F. These vaults then present up to the springing of the side arches, a group of ribs projecting from the construction, a compact mass, heavy in fact, with a certain pretense of lightness. Desiring to retain the crowns of the side arches at the level of the crowns of the diagonal arches, as we have already stated, and being evidently restricted in their combinations by the reentrant and vertical surfaces G F, the Anglo-Norman constructors took the method of raising the springings of the transverse, diagonal and intermediate arches to the level of those of the side arches. The presence of the vertical surface F G beside the curved surfaces D E was not logical for rationalists. But placing the imposts of all arches of the vault at the same level to avoid these vertical surfaces, the English architects however pretended to place the crowns of the diagonal and transverse arches on the same horizontal line. then it was necessary for these transverse and diagonal arches to be very depressed. Then in England men came to abandon the pointed arch for transverse arches and the round arch for diagonal arches, and to adopt curves composed of portions of ellipses while retaining only frankly pointed curves for the side arches, as indicated by Fig. 72; the crowns A B C are in the same horizontal plane. From these groups of ribs forming pyramids or inserted curvilinear cones to vaults composed of intersecting curvilinear

to be to have very high windows, as indicated by the section  
 to show the appearance of these vaults in the interior  
 a curve different from that of the French vaults. There is a  
 constructive view of one arching of the vaults of the choir  
 the cathedral of Elv (VI). It is seen that these arches are  
 located and give a sense of curves, a considerable portion  
 of which is visible in the interior.

It is further this effect more striking, the construction has  
 also been to combine all the arches on the apses of the choir  
 and also a common group, whose lower part we indicate (VII) at  
 the horizontal section at the level of the floor, at 0. - but it  
 the horizontal section traces a portion of a polygon resting  
 on the apses from D to E; from D to F, which is the side  
 top, it follows a curve, for the spreading of the side arch  
 and also a curve from the base of the diagonal, transverse and

transverse arches, the middle filling of these rise vaults  
 to a plane passing through D, F. These vaults have a common  
 to the horizontal of the apses, a group of ribs and  
 along from the construction, a common base, heavy in fact,  
 with a certain measure of thickness. Designed to retain the  
 weight of the side arches at the level of the crown of the

transverse arches, as we have already stated, and being everywhere  
 constructed in such a manner by the resultant and vertical  
 load, the side arches, the angle between the transverse and vertical  
 load is constant the horizontal of the transverse, diagonal  
 to the horizontal arches to the level of those of the side arches.  
 The horizontal of the vertical load is constant the horizontal

of the side arches D is not identical for transverse. The diagonal  
 of all arches of the vault at the same level to a  
 horizontal line, the horizontal of the transverse, diagonal

to the horizontal line, then it was necessary for  
 the transverse and diagonal arches to be very different. The  
 the horizontal line was to establish the pointed arch for the  
 transverse and the round arch for diagonal arches, and to  
 the curves composed of portions of ellipses while retaining  
 the transverse pointed curves for the side arches, as indicated  
 in VII. The curves A B C are in the same horizontal plane.  
 the curves of ribs forming vaults or inserted curves  
 these curves to vaults composed of intersecting curves.

cones is not far; the constructors of the end of the 14<sup>th</sup> century in England soon arrived at that last result. (72 bis). But these vaults are no longer closed by fillings of rubble masonry on cut arches, these vaults are entirely composed of large cut stones of small thickness, requiring drawings, complicated diagrams and certain artifices, for example, such as that of transverse arches hidden in the surfaces, as we have marked them by A B C on the sketch representing the extrados of the vault.<sup>1</sup>

Note 1.p.122. See Memoir of Dr. Willis on the construction of vaults in the middle ages, and the translation by M. C. Dally. Vol. 4. Revue de l'architecture.

Thus by a series of deductions, further very logical, Anglo-Norman constructors passed from the dome to these singular vaults composed of intersections of curvilinear cones, and departed entirely from French construction. In Normandy, these vaults were never adopted; but the English influence there remained something. In that province toward the end of the 15<sup>th</sup> century were often abandoned vaults composed of courses of rubble turned over arches. They also desired to use cut stone. The people of Normandy, Manche and Brittaoy voluntarily made compound vaults; either of great cut slabs decorated by mouldings inside, supported by their joints without the aid of arches, or of stone ceilings set on arches. One sees in the church of Ferte-Bernard near Mans pretty chapels of the 16<sup>th</sup> century thus vaulted.<sup>1</sup> (73). Those are slabs sculptured in coffers inside, set on stone arcades supported by diagonal arches. This system of construction is elegant and ingenious; but one would wish to see here rectangular windows, for the pointed side arches enclosing them have no reason for existence. The system of Gothic vaults must come to that, necessarily its final expression. To close the intervals left between the arches by ceilings, and at need to multiply the arches to the point of having between them only surfaces, that could be easily filled by one or two slabs, was to arrive at the limit of the system, and this was frequently attempted with success at the beginning of the Renaissance, either in religious monuments or in civil architecture. It is even proper to render this justice to the architects of the French Renaissance, that they knew how to employ with great freedom



Gothic methods concerning the construction of vaults, and that in freeing themselves from the routine in which were held the masters of the 15 th century, they applied the new forms and resources to the art of construction of the middle ages.

Note 1.p.123. The construction of these chapels dates from 1543 to 1544.

At the beginning of the 16 th century, the architects very frequently employed the system of vaults composed of slabs supported on ribs, which permitted them to decorate these vaults with rich sculptures, and to obtain effects previously unknown. Composing a sort of framework of stone with pendant keystones or rosettes at the intersections of the ribs, they set carved slabs between them. This system was often adopted, for example, to vault galleries, inclined ceilings of stairways with elliptical tunnel vaults (74). Each voussoir of the transverse rib A supports at both sides of the little pendant keystone a joint B to receive the longitudinal ribs; the slabs D simply rest in rebates on these ribs, as indicated in detail X; A' is the section of one of the transverse arches, B' one of the voussoirs of the longitudinal platbands, D' the section of the slab. This method is simple, and such construction is good and easily executed, the slabs can be carved before setting, it presents all the elasticity that the Gothic constructors had obtained in the combination of their vaults. But the artists of the Renaissance very quickly forgot these excellent traditions, and if they long retained those forms derived from a reasoned principle of construction, they cut this sort of vault like an ordinary tunnel vault, no longer regarding the framework as independent ribs.

During the 15 th and 16 th centuries, the English and Normans had attained in the construction of vaults the production of surprising effects by their combination and their richness. The architects of Ile-de-France, Champagne, Burgundy and of the Loire retained, even in this last time of the Gothic period, more sobriety; during the 16 th century, they even sought to reproduce the forms, if not the structure of the Roman vault.

When the character of the people is left to its own inspiration and is not falsified by a spirit of narrow system, it depicts itself with an entire freedom in works of art, and particularly in those which are in great part the result of



reasoning. The Normans have always been rather bold workmen than inventors, they have known from all time how to appropriate the discoveries of their neighbors, and to apply the system themselves. It is unnecessary to demand from them these efforts of the imagination, those conceptions that belong to more southern genius, but indeed ingenious and thoughtful applications, a consistent and wise execution, persistence and care in the execution of details. These qualities are found in the Anglo-Norman edifices built during the 12<sup>th</sup> and 13<sup>th</sup> centuries. It is unnecessary to require from Anglo-Normans that freedom of charm, variety and individuality, which we find in our French construction. With them a method passes for good and practical, they perfect it, extend its results, follow its progress and stop there. On the contrary with us, men always seek and perfect nothing. Anglo-Norman structures are generally executed with much more care than are ours; but to know one of them is to know all; one does not see those new and bold inspirations burst forth, that have tormented our architects of the first time of Gothic art; a true epoch of intellectual emancipation of the laborious classes of the North of France.

#### MATERIAUX. Materials.

This is interesting to observe, and it may have a consequence. The more youthful the people, the more the monuments they erect assume a character of durability; on the contrary in growing old, they content themselves with temporary structures, as if they were conscious of their approaching end. It is with peoples as with isolated individuals; a young man will build more substantially than one of seventy, for the former does not have the feeling of his end, and he seems to believe that everything surrounding him cannot last as long as himself. Now the middle ages are a singular mixture of youth and decrepitude. The old antique society still retained a breath of life; the new life is in the cradle. The edifices constructed by the middle ages manifest these two opposed situations. In the midst of peoples permeated by young and strong sap, for example like the Normans and Burgundians, the structures are built much more solidly, and assume a more powerful character than among the dwellers on the banks of the Seine, Marne and Loire, whose customs still exhibit Roman traditions in the 1



12 th century. Even the Burgundian has a considerable advantage over the Norman, in that he is endowed with an active imagination, and that his temperament is already southern. During the Romanesque period his monuments have a character of power, that one cannot find in the other French provinces, and when the system of Gothic commenced to develop, he took possession of it and applied it with singular energy. Perhaps he had a taste less sure than his neighbor, the inhabitant of the banks of the Seine or Marne; but he certainly had more than him the feeling of his strength, the consciousness of his duration, and the means of displaying these youthful qualities. It seems that the territory occupied by him came to his aid, for it supplied him with excellent materials, resistant, of large dimensions, lending themselves to all the boldness, that his ardent imagination could suggest to him. On the contrary in the basins of the Seine, Marne, Oise and the middle Loire, in old France, the materials furnished by the ground are thin, light and with little resistance; they must by their nature discard the idea of rashness, and complete the constructor to replace by ingenious combinations what the soil refused him. It is necessary to take into account the properties of these different materials, and of the influence exerted by their qualities on the methods employed by the constructors; but independently of their particular qualities of materials suitable for building, we repeat that the character of the inhabitants of these provinces presents great differences, and that influence the means adopted.

The transition is complete; of Romanesque construction there remains nothing more; the principle of equilibrium of forces has replaced the system of inert stability. Every edifice at the end of the 12 th century is composed of a framework rendered stable by the combination of oblique resistances or vertical loads opposed to thrusts, and of an enclosure, a covering, that clothes this skeleton. Every edifice possesses its skeleton and its membranes, it is no longer merely a framework of stone independent of the enclosure covering it. This skeleton is rigid or flexible, according to the need of the place; it yields or resists, it seems to possess life, for it obeys contrary forces, not passive but active. Already we have been able to appreciate the properties of this system in the descr-



description that we have given of the construction of the choir of the church Notre Dame of Chalons-sur-Marne (Figs. 41, 42, 43); but the construction appears how rude and refined at the same time, mean and complicated, if we compare it to the beautiful Burgundian structures of the first half of the 12th century. There all is clear, frank, easy to understand; of what wise boldness! The boldness of men that are certain of not failing, because they have foreseen everything, that they have left nothing to chance, and know the limits that good sense forbids passing.

We have reached the period of construction in the middle ages during which the nature of the materials employed is going to play an important part. We cannot pass over in silence observations, that must be as the introduction to the methods of building of the Gothic architects. Such a great quantity of public and private edifices were erected during the 12th century, that one cannot be surprised to find among the constructors a profound knowledge of the materials suitable for building and of the resources offered by their use. Men that could not acquire a very extended instruction, by lack of complete teaching by the successive observations of several centuries, are obliged to supplement that elementary poverty by the sagacity of their intelligence; not being able to depend on developments not in existence, they must make their own observations, collect and classify them, composing a theory from them. Practice alone directs them, only later are the rules established, and it must be confessed, that however complete the theory, however numerous and good the rules may be, they never can take the place of observations based on a daily practice. At the end of the 12th century, the constructors had moved and cut such a great quantity of stones, that they had come to know accurately their properties, and to employ these materials in accordance with these properties, with a very rare sagacity. Then it was not as today, an easy matter to procure cut stone; the means of transportation and of quarrying being insufficient, this must be supplied on the ground; it was not possible to procure stones from distant sources; it was then by means of local resources, that the architect must build his edifices, and frequently his resources were weak. Men do not take into account sufficiently these difficu-



difficulties, when they appreciate the architecture of that time, and they often place it to the account of the architect, regarding it as a puerile desire of erecting structures astonishing by their lightness, when it is in reality only extreme penury of means. Building stone in the 12 th and 13 th centuries, compared to what it is in our time, was a rare material and consequently dear; it was necessary to economize it and to employ it so as to use the smallest possible volume in structures. There is no need to resort to written documents to recognize that fact; it suffices to examine public and private edifices with some care, and one will recognize that the constructors not only did not set one stone more than necessary, but also that they only placed in the work the qualities suited to each place, economizing very scrupulously the dearest stones, i.e., those of very great durability or of great volume. The workmanship on the contrary being relatively cheap, the architects did not commit the fault of lavishing it. Besides it is sufficiently in the order of things, that when a material is dear in itself, one seeks to emphasize its value by unusual workmanship. We recommend these observations to persons, who not without reason, now condemn the servile imitation of Gothic architecture. Here is what might be said, but which has not yet been thought; "If in the 12 th century 35.3 cu. ft. of stone on an average cost \$40, and a day's work of the stonecutter 20 ¢, it was reasonable to use only the least possible stone in an edifice, and it was natural to emphasize the value of this precious material by workmanship, that cost so little. But today the stone averages \$20 per 35.3 cu. ft., and the day's work of the stonecutter represents \$1.20 or \$.40, so that there are no longer the same reasons for saving stone at the expense of stability, and for giving a material costing so little, workmanship costing so dear.<sup>1</sup> That argument would be more conclusive against the imitators of Gothic architecture, that for example, is not the comparison of the nave of a Gothic church to an inverted hull of a vessel; for that comparison is an eulogy, rather than a criticism, just as would be the comparison of the dome of the Pantheon to a straw beehive. But leave aside comparisons, that are no reasons, as the proverb says, and let us proceed. Constructors in the middle ages did not know the saw with sand, that 1

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long blade of wrought iron by means of which, by a horizontal reciprocal movement, a workman can cut enormous blocks into slices as thin as the need requires. There are still 70 departments in France in which that very simple instrument is not employed, and these are generally where they build best, for one can contest the advantages of the saw with sand. France abounds in very varied beds of limestone, very good and easily quarried. These beds as all know are hard or soft, thin or thick, usually thin when they are hard and thick when soft. Now it is always advantageous in construction to respect the order of nature; that is what the ancients frequently observed, and is what was most scrupulously observed by the Gothic constructors. They quarried and employed the materials such as afforded by the beds of the quarries, even subjecting the architectural members to the heights of these beds. Never doubling the stone as we now see done on our yards, they set them entire in their structures, i.e., with their heart retained in their middle part, their lower and upper beds, contenting themselves with cleaning them.<sup>1</sup> This method is excellent; it preserves to the stone all its natural strength, all its means of resistance. If Gothic constructors of the first time employed soft stones for points of support (which they were often forced to do for lack of finding others), they took care to use them with a great height of bed; for in that case soft stone is less subject to crushing. As for hard stone and the thinnest among others, which are generally the strongest, they used them as bands, continuous lintels to connect together distant piers, they formed the points of support of them, which should bear a very heavy load, either by piling them on each other, if these supports were very thick, or by placing them on edge, if the supports were slender. With regard to stones set on edge, one recognizes all the acuteness of observation of the constructors. They were not ignorant that stones set on end are subject to split, so they chose them with particular care in lower beds, very homogeneous and compact, in the gypsum at Paris, in the hard stones of Tonnerre,<sup>1</sup> in lower Burgundy and Champagne, in the thin beds of upper Burgundy, hard as sandstone and without seams.<sup>2</sup> Experience had taught them that certain hard stones of fine grain, like the gypsum of the little hard bed of Tonnerre, for example, composed of



thin layers of limestone, superposed and connected by a solid cement; that these stones by their texture itself, had when set on end a sort of counter grain of extraordinary strength; that they resisted enormous pressures, and that strongly held under a great load, they split less easily than if set on bed; for what causes these stones to split is the dampness that they collect between their thin layers and that swell their marly layers; now set flat, they are more apt to retain this dampness than if set on edge. In the last case the water slips over their surfaces and does not penetrate the superposed layers. As proof of what we have advanced, we can cite a number of gutters, drips, cornices, flag stones of lias or gypsum in very old edifices, set on bed and often found split; while the same materials in the same monuments set on edge are perfectly preserved, only split by accidents, such as rusting of cramps or pins, or by some defect. We must not omit here an important fact in the structures of the middle ages, which is that the beds are cut with the same perfection as the visible surfaces, and that the stones are always set in a bed of mortar, and not jointed or cast, which is worse. At most and to terminate this digression concerning materials suitable for building, we shall add that the constructors of the first Gothic period subjected their system of construction to the materials at their disposal, and consequently the forms of their architecture. A Burgundian architect in the 12th century did not build at Dijon as at Tonnerre; if one finds in the same province the influence of the same school, in the execution of the masonry will be noted considerable differences resulting from the nature of the stone employed. But as in each province there is a dominant quality of material, the architects adopted a method of building conforming to the nature of these materials. Burgundy, so rich in stones of superior quality, supplies us with the most evident proof of that fact.

Note 1.p.128. Perhaps some one will ask how it can be that stone was so dear while the work was so cheap, since stone only acquires value by being quarried. To that we reply that quarrying may be done with more or less skill, and by means of machines more or less powerful; that a very advanced industrial condition always brings a reduction of price of raw ma-



materials, by facility in quarrying, transportation, and because the use of perfected machines, for example, 35.3 cu ft. of stone only \$1.00 for transportation for 2. miles by canal, and would cost \$4.00 or more if brought the same distance in wagons; if the roads were bad, the difference would be greater. Now that is what occurred in the middle ages, not counting the dues of the rights to quarry, that were often enormous. Centralization is one of the most certain means of obtaining raw materials cheap. Formerly there was not an abbot or lord over whose lands it was necessary to pass, who did not charge for the right of crossing, and these dues being arbitrary, there resulted a considerable increase of the cost of quarrying. And the proof that this was so is, that we see, for example, monastic establishments frequently go to seek stone at enormous distances, because it came from quarries belonging to them, and that they only had to follow the roads free from all dues, while they did not bring materials from very near, that required the crossing of lands belonging to owners not vassals of the abbey.

Note 1. p. 129. To clean stone is to remove from its two beds the parts of the limestone that preceded or succeeded complete geological formation; in brief, to remove the parts liable to decompose by action of air or dampness.

Note 1. p. 130. Those hard beds of Tonnerre are no longer quarried, although their qualities are excellent; they are called "stones of wood".

Note 2. p. 130. Stones from Manse, Dornecy, Ravieres, hard from Coutarnoux, Anstrude, Thisy and Pouillenay.

DEVELOPPEMENTS. (XIII SIECLE). Developments in the 13th Century.

At Dijon exists a church of moderate size under the name of Notre Dame; it was built about 1220; it is a masterpiece of reasoning, where science of the constructor is concealed under apparent simplicity. We shall commence by giving an idea of the construction of that edifice. The chevet is without side aisles and opens into the crossing; it is flanked by two chapels or little apses orientated like the sanctuary and opening into the transepts in the prolongation of the side aisles of the nave.

The apse of Notre Dame of Dijon is composed internally of



only of a thick and low substructure bearing isolated piers connected in all directions, and having for external enclosure only a sort of partition of stone pierced by windows. Naturally the piers are designed to support the vaults; as for the walls, they support nothing, being merely an enclosure. On the exterior the construction consists only of buttresses. Fig. 75 gives a perspective view of that apse; being without side aisles, the buttresses directly abut the vaults without flying buttresses.<sup>1</sup> These buttresses are thick and solid; in them alone resides the stability of the edifice. Nothing is more simple in appearance and in fact than that construction. Thin walls pierced by windows close all spaces left between the buttresses. An external passage at A is left to facilitate the repairs of the great stained glass windows. All surfaces are well protected from rain by slopes without projections of cornices or bands. This is evidently only a solid enclosure, a shelter. Let us now enter the church of Notre Dame of Dijon. Just as the exterior is simple, solid, covered and sheltered, so the interior presents light and elegant arrangements. This monument was and still is built in a populous quarter, surrounded by narrow streets, the architect thought he must sacrifice all to the internal effect. One further recognizes that he must have been limited in his expenses, to avoid useless costs. He is not lavish with materials, he has not wished to set an unnecessary stone. Then the apse (76) is internally composed of a solid substructure A, thick and built in courses, decorated by an independent arcade as a facing. From that substructure already rise the little columns B, which ascend to the springing of the arches of the great vault. These little columns are set on end from the base of the band C, which connects them by a ring with the external construction. On that substructure is a passage or service gallery designed to facilitate the maintenance of the stained glass windows D and to hang the church if necessary on festal days. The piers E are isolated; they are composed of four columns set on end from base to capital, one large (14.6 ins. diameter) and three small ones (4.7 and 5.9 ins. diameter). At A' we give the section of these piers. The great column and the two side columns are each of a single piece as far as the course F of the capitals, while the little column rising from the



pavement is of a single piece up to the slab G. This slab G forms the ceiling over the low gallery and connects the great arcade with the external surface. In the height of the gallery of the third story (triforium) is the same arrangement of the piers, the same section A'; only that an intermediate little column H supports an arcade likewise composed of great pieces of thin stones, like slabs set on edge. Above the triforium a second series of slabs I serves as ceiling of that triforium and connects the arcade to the external construction; then spring the arches of the great vault abutted by the external buttresses. The high windows then open over the arcade of the triforium, and are no longer recessed below, in order to give all light possible, and to leave on the exterior the passage mentioned above. Thus the thrust of the arches is transferred obliquely to the external buttresses, which are built in courses, and the internal piers are only rigid points of support, incompressible, since they are composed of great stones set on edge, but which by their small bearing only present a shell able at need to incline from one side or the other, outward or inward, without danger, even if a settlement remains. As for the walls K, as we have already stated, they are merely partitions at most 4.0 ins thick. Let us now remove from this structure all that is merely accessory to take its skeleton, when we shall find (77); A is a built buttress, a passive mass; B is a slender support though rigid; resistant like cast iron, due to the quality of the limestone employed; C is a course above the arches, consequently flexibility at need; D a connection of the interior and exterior; E a second support, but shorter than the lower one, for the monument rises and the movements produced will be more serious; F a second course joining the interior and exterior; G are impostes; H are simple enclosures with nothing to support and only serving to enclose the edifice; I the abutment only where acts the thrust of the arch. Nothing too much but all that is necessary, since this construction has maintained itself more than six centuries, and does not appear near to its ruin. It is necessary to recall here what we have said concerning the function of the monolithic little columns, which accompany the columns B and E, and that we have assumed to be removed in Fig. 77; they are only the accessory supports that give firm-



firmness and bearing of the principal columns, without being absolutely indispensable. The load of the vaults rests very safely on the buttresses, because of the action of the thrust on the cylinders B E (Fig. 23). The internal group of little columns supporting only a very small load, there was no need to give them great strength. But if we have a side aisle, if the buttresses, instead of being directly opposed to the action of the vaults, be removed from them by the entire width of the side aisle, then the vertical piers must have more bearing, for they really carry the weight of the vaults.

Note 1.p.131. We may indeed be permitted an observation on this subject; in appreciating more or less the merit of Gothic religious edifices, some critics (who are not architects, it is true) have claimed, that of the churches of the middle ages in France the most perfect, that which indicates on the part of the architect the greatest talent, is the S. Chapelle of Paris, for that retains a perfect stability without the aid of flying buttresses; and starting from that, the same critics, doubtless happy in having made that discovery, have added; "The flying buttress, a permanent stone shore marks the lack of power of the constructors, is only a barbaric superfluity, a useless sport, since during the middle ages skilful artisans have known how to do without it." The argument is strong; but the S. Chapelle has no side aisles; hence the architect was not compelled to cross that space and transfer the thrusts of the great vaults to the exterior outside the side aisles. However it is, others that one always speaks of an art unknown to him; and the multitude applaud him, for practitioners do not believe it necessary to refute such arguments. They are wrong; an error repeated a hundred times, were it one of the most gross, but repeated with assurance, ends with us in being accepted among the least contestable truths; and we still see printed today with the best faith in the world, on the arts and especially on Gothic architecture, arguments refuted long ago by the criticism of the facts, by history, by the monuments and by demonstrations based on geometry. All this labor for truth, that desires to appear to pass unperceived by the eyes of certain critics, who probably claim to forget nothing and to learn nothing.

The nave of the same church of Notre Dame of Dijon is vaul-



vaulted according to the primitive Gothic method. The diagonal arches are on a square plan and are intersected by a transverse arch. The lower piers are cylindrical, built in drums and of equal diameters. However the capitals differ in pairs, for they alternately support either a transverse arch and two diagonal arches, or only a transverse arch. Here (78) is a view of the internal bay of the nave of Notre Dame of Dijon. At A' we have traced the section of the impost A', at B the section of the impost B, with the horizontal projection of the abacuses of the capitals. These capitals bear a greater projection at the side of the nave, to receive the little columns that ascend to the springings of the vaults, always because of that principle, which consists in separating the vertical points of support so as to take a part of the thrusts. (Fig. 34). At C' we give the horizontal section of the piers C', at D' that of the piers D at the level of the triforium, at E' being the horizontal section of the imposts E and at F' that of the impost F at the level of the abacuses receiving the great vaults. This general view being presented, let us now examine with care the structure of this nave.

We have already stated, that the architect of the church of Notre Dame of Dijon disposed of a small site, shut in between narrow streets; he could not give to the buttresses of the nave, staying the entire system, a strong projection beyond the perimeter of the side aisles. If he had followed the methods adopted in his time, if he had submitted himself to routine, or more correctly, to the rules already established by experience, he would have traced the flying buttress of the nave as indicated by Fig. 79. The thrust of the great vault acting from A to B, he would have placed the last voussoir of the arch at A and its loping at P, and he would have advanced the face of the buttress to C, so that the oblique line of the thrusts should not pass outside the point G. But he could not leave the limit I; the width reserved for the public street did not allow this; on the other hand he could not internally go beyond the point K, which is vertically over the engaged internal pier L, without having an overhang and breaking the transverse arch M, whose curvature it is important to preserve; for if too great weight acts on the haunches of that arch at N, that arch would push the isolated internal pier in



the direction O P. Then the architect must establish the pier of his flying buttress in the space between K and I'. But we know that this pier must be passive and immovable, for it is the true support of the entire system; it can evidently acquire that immobility (Its narrow bearing being assumed) only by a particular combination, the complement to the vertical resistance. Here then is how the constructor solved the problem; he built the pier between the two desired points; (79 bis); he strongly loaded the head of the flying buttress at A; he inclined the coping B C so as to make it tangent to the extrados of the arch, then he brought the rear face of the pinnacle D as an overhang to the point E beyond the surface F, so that the space P F may be a little less than a third of the space F G. Thus the thrust of the great vault is strongly compressed by the load A, and is neutralized by that pressure; it is then only the flying buttress that itself acts on the pier K, as far as it is loaded at A. If then this arch must be deformed, this would be according to the sketch R; it would break at S and the pier K would be inclined. But the architect recedes his pinnacle, loads the pier beyond its vertical to the point E, i.e., to the point at which the rupture of the flying buttress would occur; thus he arrests that rupture, for under the load the point S' of the flying buttress cannot rise; but the pinnacle D cannot compress the arch, it does not load it, since the space C O is greater than the space O P; then the load of the pinnacle, which is a well built homogeneous construction with great cut stones, rests on O C, the centre of gravity of the pinnacle being between O and C; then if the arch were demolished this pinnacle would remain standing; then he loads the pier K with a weight superior to that of the pinnacle having only a width F G; thus he assures himself of the stability of the pier F G, too weak by itself to resist the thrust without the addition of that load, and at the same time he compresses the haunch of the flying buttress at the point where that arch tends to break by rising. The fact is still better proof than all the logical deductions; the construction of the nave of Notre Dame of Dijon, in spite of the neatness of its external buttresses, has not suffered the least deformation. Do not lose sight of the interior; observe that the vaults do not thrust directly on the head



of the flying buttress, and that between the head of this arch and the impost of the vault there exists above the triforium U an internal buttress V only because of that thrust, and that singularly neutralizes its action. Study the details: the block of stone T, against which abuts the last voussoirs of the flying buttress, is only the lintel supporting the buttress first mentioned, and in the height of the same lintel are made the two capitals, that support the side arches of the vault (Fig. 78). This lintel is set exactly at the level of the action of the thrust of the great vault.

Let us dissect this construction piece by piece (80). We see at A the column, the principal support of the triforium beside the piers that carry the springing of a transverse arch and of two diagonal arches, a column flanked by its two little columns B. At C are the large shafts set on end, that rest on the abacus of the great capital of the ground story, and that pass before the group A B B to come beneath the course M of the capitals of the arches of the great vault; a course of a single block. At D is the capital of the triforium. At E is the impost of the arcade of the triforium also in one block. At F are the two blocks forming an arcade. At G is the course of the ceiling of the triforium connecting the arcade of the course of the capitals M with the external buttress u under the roof, the buttress whose courses are traced at H. At G' is one of the slabs set beside G and connecting the rest of the arcade with the wall built beneath the upper windows, with the sill I. These slabs G' support the drip K covering the roof of the side aisle. At L is the first block of the external buttress seen above the roof. At M is the course of the capitals of the great vaults bearing the two bases of the little columns set on end for the side arches. At N is the impost of the great vaults with upper bed horizontal, and that supports the springings of the two diagonal arches and of the transverse arch. At O is the second impost bearing the two diagonal arches and the transverse arch, the upper bed of that being already normal to the curve, while the beds of the two diagonal arches are still horizontal. At P is the third impost block no longer bearing the transverse arch, which is independent, but still bears the two diagonal arches with horizontal upper beds. At Q is the fourth impost block bearing



only the projections behind the diagonal arches for setting the first rubble courses of the filling. At R is the lintel just mentioned, connecting the impost blocks of the pier whose curves are traced at S. this lintel bears the projections behind the diagonal arches, for it is important to shore those diagonal arches already independent, and whose voussoirs are sketched at T, while one of the voussoirs of the transverse arch is shown at V. At X is the course of the external buttress bearing the end of the window sill, the bases of the little external columns of these windows, and a fillet passing above the fillet at edge of the roof, as indicated by the perspective sketch. The impost voussoir of the flying buttress then abuts against the lintel K, and above that lintel the space between the pier S and the vault is solid. (See internal view, Fig. 78).

If we examine the section in Fig. 79 bis, we see that the buttress X, the wall of the triforium Y, the passage Z of the internal pier present a considerable thickness; for the passage is quite wide; the wall and the buttress are together about 2.0 ft, and the group of columns composing the internal pier are 1.6 ft. Now all that must rest on a single capital crowning a cylindrical column. There will evidently be an overhang, and if the buttress X comes to rest on the haunch of the transverse arch of the side aisle, the pressure exerted by it will push the column to the interior, cause it to lose its vertical position, and once this is lost, the entire equilibrium of the construction is destroyed. The constructor at first gave the capital the form A (81); i.e., he brought the axis of the column into the vertical plane passing through the middle of the archivolt B. On this capital he placed two impost blocks C D with horizontal beds; the first block C bearing the bases of the little columns set on end, ascending to the springing of the great vaults; the third block E bears the cuts normal to the curves of the transverse and diagonal arches and archivolts, for above that block the arches separate from each other. Freed from the arches, which are then set as independent voussoirs, the constructor has erected a pier of harp form F G H I K and corbelled out of the buttress L; in the course I he took care to reserve two projections M to receive the discharging arches supporting the wall N of the



the triforium. The internal pier O, as we have stated, composed of a group of little columns on end, rests on the internal surface of that pier. It is understood that the courses F G H I X are each of a single block of stone and are strong. The heaviest weight and greatest resistance presented is that of the pier O, since it supports vertically the vaults abutted; the buttress L bears almost nothing, for the head of the flying buttress does not load it (Fig. 79 bis), it only equilibrates the structure. Then the stones K I H, being loaded at the ends K' I' H' cannot tip over; thus the buttress is supported. As for the thrust of the transverse arch P and of the diagonal arches of the side aisle, it is completely neutralized by the load resting vertically on the pier O. One now understands how essential it is that the pier O be composed of large stones set on end and not in courses, for that pier supports a double effect of compression; that from top to bottom because of the load of the vaults and that from bottom to top because of the tipping produced by the buttress L on the ends of the stones K I. If then these piers O were built in courses, this might cause the mortar joints strongly compressed by the double action to diminish in thickness; then the least settlement in the height of the piers O would result in deranging the entire equilibrium of the system. On the contrary, the lever action produced by the courses I' and K under the pier O would have as a result (these piers being perfectly rigid and incompressible) to very energetically support the springing of the great vaults.

One can better take into account this system of construction by assuming, for example, that there has been employed for executing it cast iron, stone and wood (82). Let a cast iron column and its capital A be set under a stone block bearing a stone impost B. The constructor makes a greater projection toward the nave of the capital than toward the side aisle. O On this capital he erects the courses B C D E F G, etc., with corbellings. He sets three cast iron columns H along the internal surface, doubled by three other columns " (see section H"), these columns H H' are connected to the buttress I by collars and an anchor K, so as to make the buttress solid with the pier A and to prevent their separation. The buttress I is built in courses of stones. On the columns H H' the arch-

the structure. The internal pier 7, as we have stated, com-

posed of a group of three piers, as well as the other

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architect places the imposts L of the great vault: the two lateral columns O O alone continue to the lintel M, that abuts the arches of the great vault. On the exterior he erects a pier N of stone in order to maintain the internal supports in the vertical by means of the shore P held by the twin ties R to prevent its rising. There is no inconvenience in this, on the contrary, if the abutment I built in courses is compressed and settles, for the more the point O is lowered, the more the shore P will be pressed against the tail of the lintel M in a horizontal plane, but especially to give stability to the column A. Indeed, it is unnecessary to be greatly versed in the knowledge of the laws of equilibrium to know, that if between the column Y and a column S, both being slender (82 bis), we place several horizontal courses, it will be impossible, however loaded the column S, and however well stayed the courses may be in one direction, to maintain these two columns in a vertical plane parallel to the plane of the shores; while placing on a column T (82 ter) horizontal courses V, shored in one direction, and on these courses two supports or columns X X' passing in a vertical plane perpendicular to the plane of the shores, assuming also that these two columns X X' are loaded, we could maintain the columns X X' and T in planes parallel to the shores. In that consists the entire system of the construction of Gothic naves resting on columns. There is the explanation of the superposed galleries of Burgundian architecture, a sort of open buttress with its internal surface rigid and its external surface compressible, thus giving great power of resistance and bearing for the springings of the high vaults, avoiding enormous spandrels for abutting the flying buttresses, and destroying by its equilibrium and its pressure on two different points the effect of the thrust of the vaults of the side aisles.

Indeed all that may appear complicated, subtle and labored; but one will indeed recognize without that it is ingenious, very skilful and wise, and that the authors of this system have made no confusion of Greek art with the art of the North, of Roman art with oriental art, that they have not put caprice in place of reason, and that in these structures is better than the appearance of a logical system. We admit fully that one may prefer a Greek, Roman or even Romanesque construction

columns of the great vault, the two I  
 and column C alone continue to the level V, that is  
 the system of the great vault. On the exterior no stress  
 is put upon it in order to maintain the internal support in  
 a vertical position of the great vault by the side of  
 the great vault. There is no inconvenience in this, on  
 the contrary, all the support I built in courses in courses  
 and columns. For the more the point C is lowered, the more  
 the great vault will be crossed at the level of the level V  
 a horizontal plane, but especially to give stability to a  
 column as tested, it is necessary to be greatly varied  
 the thickness of the face of equilibrium to know, and if  
 the column V and a column S, both being slender (22  
 ft. in diameter) horizontal courses, it will be necessary  
 to, however tested the column S, and however well covered  
 a column will be in one direction, to maintain these two  
 columns in a vertical plane parallel to the plane of the great  
 vault resting on a column T (22 ft) horizontal courses  
 tested in the direction, and on these courses two supports  
 column V' passing in a vertical plane perpendicular to  
 a plane of the great vault, assumed also that these two columns  
 are tested, we could maintain the column V' and T in  
 a plane parallel to the great vault. In that position the great vault  
 is in the position of a column V' resting on column  
 and in the position of the great vault, the effect of the  
 great vault, a sort of open chamber with its interior  
 surface rigid and its exterior surface compressible, thus  
 the great power of resistance and bearing for the great  
 vault of the great vault, and resistance by its equilibrium  
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 effect of the vault of the side walls.  
 Indeed all that may appear complicated, simple and logical;  
 one will indeed recognize with us that it is rational,  
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 is the result of Greek art which was not of the North.  
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 of reason, and that in these structures is better  
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 the Roman or even Byzantine construction

to that of the church of Notre Dame at Dijon; but he would indeed permit us to believe, that more is to be found here for us, architects of the 19th century, called to erect very complicated edifices; to play with the material, possessing materials very different by their nature, their properties and the mode of using them; forced to combine our structures in view of new needs, very varied programmes, very different from those of the ancients; that more is to be taken, we say, than in the primitive structure and so simple of the temple of Minerva at Athens, or even in the concrete and immovable construction of the Pantheon of Rome. It is sad that we cannot always build like the ancients, observing perpetually those simple and beautiful rules of Greek and Roman constructors; but we cannot reasonably erect a railway station, a hall, an assembly hall, a bazaar or an exchange, by following the vagaries of Greek or Roman construction, while the flexible principles already applied by the architects of the middle ages, if studied with care, place us on the modern path, that of incessant progress. This study permits us easy innovation, the use of all species of materials, without derogating from the principles set by architects, since these principles consist exactly in subjecting all, materials, form, arrangements in general and detail, to reasoning; to attain the limit of the possible, to substitute the resources of the industries for inert force, the search for the unknown for tradition. It is certain that if these Gothic constructors had had at command great members of cast iron, they would not have failed to employ that material in buildings, and I cannot but state, that they would have soon reached results more judicious and better reasoned, than those obtained in our time, for they would have frankly taken that material for what it is, profiting by all the advantages it offers, and without occupying themselves in giving it forms other than those adapted to it. Their system of construction would have allowed them to employ simultaneously cast iron and stone, a thing that no person would dare to attempt in our epoch, so much effect has routine on our constructors, who do not cease to speak of progress, like those opera singers, who say "let us go" for a quarter of an hour without stirring from the stage. We do not know that it has been attempted in France until this day, unless in the c



construction of houses of some great cities, to support considerable masses of masonry, vaults of brick or even of stone, good construction well reasoned and jointed, elegant and stable, on isolated supports of cast iron. Indeed classical instruction can scarcely permit these attempts, that the architects of the middle ages would certainly have not failed to make, and probably with entire success.

As for stopping in the path, this is not what one can reproach Gothic architects, we shall see with what ardor they threw themselves into the application more and more rigorous, of the principles that they had established, and how they arrived in a few years in pushing to the limit those principles, in employing materials with an exact knowledge of their properties, in playing with the most complicated problems of descriptive geometry.

The church of Notre Dame of Dijon is a small edifice, and one could believe that the Burgundian architects of the first half of the 13<sup>th</sup> century had not dared to allow themselves similar boldness in monuments of great extent in area and very high. The contrary occurred; it seems that working on a vast scale, these constructors assumed even more, and developed with even greater freedom their means of execution. The choir of the cathedral of S. Etienne of Auxerre was rebuilt from 1215 to about 1230 over a Romanesque crypt (Art. Crypte), which caused the adoption of certain arrangements unusual in the great churches of that epoch. Thus the sanctuary is surrounded by a simple side aisle with a single square apsidal chapel. As for its construction it presents a perfect analogy in the lower work to that of the church of Notre Dame of Dijon. Yet at Auxerre the construction is still lighter, and certain differences resulting from the Romanesque arrangements of the plan, that it was desired not to change, have been solved in the most ingenious manner.

We give (83) the half of the plan of the apsidal chapel placed under the name of the Holy Virgin. This plan is taken at the height of the gallery of the ground story, resting on an arcade, as at Notre Dame of Dijon. At X we have sketched at a smaller scale the horizontal projection of the vault of the side aisle before that chapel. Following the Burgundian method, the side arches are detached from the wall; they rest on



little columns set on end, A B, C D, E F, G H, etc.. Middle columns set on end support the effect of the pressure, and the vault is composed of two diagonal arches I K, L M, and a transverse arch N O, that of two intermediate arches P Q, R S. These two intermediate arches at the side aisle rest on two isolated columns Q S, set on end and each of a single piece having 9.5 ins. diameter and 21.7 ft. height from below the capital. The difficulty was to neutralize so accurately the different thrusts acting on these columns Q S, that they could not leave the vertical. This was a problem to solve similar to that set before the architect of the chapels of Notre Dame of Chalons-sur-Marne, but at a much greater scale and with incomparably more slender supports. Let us place ourselves for an instant in the side aisle and look at the top of the column S, whose diameter, as we have already stated, is only 9.5 ins. On that column is set a capital with octagonal abacus, large enough to receive the springing of the two arches S T and S R; with two little columns supporting the transverse arches S Q, S Y. A high impost with lower bed at A (84) and upper bed at B, is reinforced at the angles remaining between the arches and the little columns by bands of leaves. Up to the level of the abacus of the capital C, the arch D of the side aisle rises and already curves by means of two other impost blocks with horizontal beds, while the arch E (intermediate in the chapel) with a greater diameter, rather departs from the vertical, and above the bed B is composed of independent voussoirs. The little columns F of the transverse arches of the entrance of the chapel are monoliths and shore these imposts, stiffen them, and rest firmly on two sides of the abacus. Fig. 8, gives the section of that springing of the vaults at the level G H. This construction is bold, it cannot be denied; but it is perfectly stable, since for six centuries and more it has suffered no alteration. We see there one of the most ingenious applications of the system of the Gothic vault, the unequivocal proof of the freedom of the constructors, of their surety of execution, and of their perfect knowledge of the resistance of materials. These little columns are in hard stone from Tonnerre, like the imposts. As for the effect produced by that chapel and its entrance, it is surprising, but without inspiring that anxiety caused by every too



bold experiment. The arches abut each other so well in reality, and also in appearance, that the eye is satisfied. Up to that quadruple band of leaves above the capital that increases the body of the lower impost, all concurs to reassure the observer. But perhaps some one will object, why are these two columns set at the entrance? Why was not the architect contented by showing a transverse arch from one angle pier of that chapel to the other? To that is only one reply; let us return to Figs. 41, 42, 44 of this Article, and the explanation is given; he did this because of the radiating arrangement of the side aisle, to obtain on the external ferimeter a greater number of points of support than on the internal perimeter, so as to have transverse arches nearly equal in span and exactly equal in rise to close the triangles of the vaults at the same level.

If the vaults of the chapel of the Virgin and of the side aisle of the cathedral of Auxerre are arranged like most Burgundian vaults of the 13th century, i.e., if their side arches are detached from the walls, and if a slab bearing a gutter unites these side arches to the tops of those walls, the architect of the choir probably did not think this system of construction was solid enough to terminate the great vaults of the principal nave. He must have feared the clusters of this system in a very vast edifice, and he took a mean between the systems of champagne and of Burgundy.

The Champagne system consists indeed in isolating the side arch from the wall, but turning between this side arch and the wall a tunnel vault on the extrados of the said side arch. Let us then examine in what consists the Champagne system. We see it at its climax in a little edifice of the Marne, the church of Rieux near Fontmirail. Here first (86) is the half of the plan of the apse of that pretty church. One sees that this plan much resembles that of the apse of Notre Dame of Dijon. But we are in Champagne, on the area where resistant materials of great dimensions are rare; thus the little piers A are no longer composed of columns set on end; these are groups of little engaged columns having a section sufficiently large to be built in courses. Further, these little piers are short instead of being tall. Now examine the apse of Rieux. In the interior (87); we see at B concentric tunnel vaults on



the side arches, enclosing the windows and separating the carpentry of the roof and the external cornice.<sup>1</sup> Thus here are two adjacent provinces, Burgundy and Champagne, each strating from the same principle of construction; but in the first of these provinces materials suitable for masonry are abundant, firm, easily quarried in large blocks; the construction exhibits the particular properties of the Burgundian limestone; in the second on the contrary, one finds only beds of chalk, marly stones, not very solid, only quarried in small blocks; the architects subject their mode of construction to the nature of the stones of their province. The church of Rieux dates from the first years of the 13 th century; the sculpture belongs almost to the 12 th century. Champagne is in advance of Burgundy and even of Ile-de-France, when it concerns the development of the principle of Gothic construction. Already the windows of the apse of Rieux have mullions set on end, while in Ile-de-France, one hardly sees them appear for twenty years later, and in Burgundy only about 1260. The method indicated in Fig. 87 for the construction of the vaults and their supports, is already applied in the absidal chapel of the church of S. Remy of Rheims, earlier by twenty years than the apse of Rieux; it is developed in the cathedral of Rheims, in the vaults of the chapels of the great nave. (Arts. Cathedrale, Fig. 14; Chapelle, Fig. 36).

Note 1.p.151. M. Millet was quite willing to draw for us this charming and very little known edifice, and perhaps the best type of the architecture of Champagne of the beginning of the 13 th century.

Let us now return to the cathedral of Auxerre; examine the use its architect knew how to make of the two methods of Burgundy and of Champagne. Here (88) is a view of the interior of the high choir; we have assumed one of the great windows to be removed, to allow us to see how the flying buttresses about the vault, and how the internal buttress is pierced at the height of the triforium and the gallery over it. At A is distinguished the tunnel vault turned between the side arches and the archivolt of the windows; but by a concession to the Burgundian system, this tunnel vault does not spring from the capitals B, as in Champagne; it only commences a little higher on a lintel C placed on the side of the internal buttress.



This tunnel vault is here placed on the extrados of the side arch and is independent, while in the construction of Champagne, the tunnel vault and the side arch form but one, or rather the tunnel vault is only a very wide side arch. The mullions of the windows are built in courses, and not composed of columns and tracery set on edge. We give at D the horizontal section of the high pier at the level E; at F the section of the pier at the level G of the triforium. According to the Burgundian principle, these piers are set on edge in the entire height of the passages. The cornice and the upper gutter are not then placed on a slab roof as in the side aisles of the chapel of the Virgin in the same edifice, but on the arches A. The carpentry of the roof is placed on the side arches. The upper gutter discharges its water on the copings over the tracery, loading and consolidating the flying buttresses. These copings are sufficiently resistant and thick, well supported by the tracery, whose mullions are quite close together, so as to form an actual stone shore opposing its rigidity to the thrust of the vault. Fig. 89 gives an external view of one of these flying buttresses, very well constructed and well sheltered by the projections and the coping.

Let us leave for an instant the provinces of Champagne and Burgundy to examine how during the same space of time, i.e., from 1200 to 1250, the methods of Gothic construction had advanced in the French provinces, Ile-de-France, Picardy and Beauvoisis.

One of the qualities peculiar to Gothic architecture (and perhaps the most striking) is that one cannot study its form, appearance and decoration independently of its construction.<sup>1</sup> One can deceive with Roman architecture, because its decoration is merely a vestment, that is always perfectly adapted to the thing it covers, one cannot deceive with Gothic architecture, for this architecture is first of all a construction. It is principally in the edifices of Ile-de-France, that one can prove the application of that principle. We have seen that in Burgundy, thanks to the excellent quality of the materials and the possibility of quarrying them in great blocks, the architects allowed themselves a certain boldness, that might pass for being forced. The architects of Ile-de-France or their school cannot be reproached with this defect; the constr-



constructors are wise, they know how to keep within the limits imposed by the material, and even when Gothic architecture throws itself into exaggeration of its own principles, they still comparatively retain moderation, which is the stamp of men of taste.

Note 1.p. 155. We have been frequently called to defend projects of the restoration of Gothic edifices, and to give reasons for the necessary and considerable expenses to save them from ruin. In the very natural hope to obtain economy, men have often repeated to us:-- "Do only what is strictly necessary, leave to better times the care of finishing, carving the facing, etc." The reply was difficult, for it would have been necessary to give a course in Gothic architecture to the persons giving us this advice, to cause them to understand that in Gothic edifices all belongs together, that the stone is set faced and carved, and that really one cannot construct a Gothic monument while leaving something to be done to those who come after us. From the point of view of art, is that then a defect? On the contrary, is it not the finest praise, that one can give an architecture, after having demonstrated it to say that all constituting it is so intimately connected together, that its decoration makes so much a part of its construction, that one cannot separate one from the other?

The banks of the Seine and the Oise possess excellent beds of limestone, but whose layers are thin when the materials are hard, thick when soft; at least this is a general law. Structures erected in these basins are subject to this law.

The entire front part of the cathedral of Paris was erected after the first years of the 13th century; as for construction, it is an irreproachable work. All members of the immense western facade, superior in scale to all built at that epoch, are accurately subject to the dimensions of the materials employed. The heights of the layers have determined the heights of all parts of the architecture.

So far, in regard to the primitive constructions of the Gothic epoch, we have scarcely given only edifices of moderate dimensions; now procedures that may be sufficient when it concerns the construction of a little edifice, are not applicable when it is necessary to raise enormous masses of materials to a great height. The lay architects of the 13th century w

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were consummate practitioners, and understood that law very well, now forgotten in spite of our scientific progress and our theoretical knowledge of the strength and resistance of the materials suitable for building. The Greeks rarely erected but small monuments, relatively to those of the Roman epoch, or if exceptionally they exceeded the ordinary scale, it must be recognized that they did not subordinate the forms to this change of dimensions; thus for example, the great basilica of Agrigentum known under the name of temple of the Giants, reproduced in colossal size forms adopted in much smaller temples; the engaged capitals of that edifice are composed of two blocks of stone placed side by side. To make an engaged capital by joining two stones side by side, so that there is a joint in the axis of this capital, is an enormity in principle. In the same monument, the colossal figures, which were probably set against the piers and formed the second internal order, are sculptured in such thin courses of stone, that their heads consist of three blocks. To make a statue or caryatid, even if colossal, by means of superposed courses, is again an enormity for a true constructor. The joints were concealed under painted stucco, which disguised the poverty of the jointing; from our point of view, placing ourselves in the place of Gothic construction, ignorance of the principle is no less evident. But it is necessary to judge the arts by applying to them their own principles, not by applying to them principles belonging to foreign arts. We are not there conducting a trial against Greek architecture; we only state a fact, that we demand that men judge Gothic architecture by taking its own elements, its code, and not by applying to it laws not made for it.

The Romans had only a single mode of building applicable to all their edifices, whatever their dimensions; our readers know already, that the Romans cast their edifices in or on a mould, and faced them with a purely ornamental covering, that adds or detracts nothing from its stability. That is excellent and reasonable; but that has no relation to Gothic architecture, whose appearance is only the result of the construction.<sup>1</sup>

Note 1. p. 157. Perhaps we may be accused of repeating ourselves in the course of this work; but the prejudices it is nec-



necessary for us to combat are only the result of error or of false appreciation repeated with unusual persistence. In such a case, in order to make its rights apparent, truth has no other resource than to employ the same tactics.

Let us return to our starting point. We shall say then, that the Gothic architects of the 13th century subjected their mode of construction to the dimensions of the edifices, that they desired to erect. There is a very simple law that all can understand without having the least notion of statics; it is this, building stones being given and having a height of layer 15.7 ins., for example, if we build a pier 10.5 ft. high with these stones, we shall have 9 parallel beds in the height of the pier; but if with the same materials we build a pier 21.0 ft. high, we shall have 17 beds. If each bed joint suffers a depression of 0.39 in. for the small pier, the settlement will be 3.5 ins., and for the large pier 6.7 ins. Again it is necessary to add to this settlement resulting from the number of bed joints a greater weight, which adds a new cause of settlement for the large pier. Thus the more the constructor piles the stones on each other, the more he increases the chances of settlement, because of cracks and of instability of the different members of his edifice, since if that be enlarged, the materials are the same. These differences are not sensible in edifices differing little in dimensions, or when one consents to place an enormous excess of strength in his structures; but if he only wishes to put in the work just the quantity of materials necessary, and if with the same materials, one desires to erect a facade like that of a village church, and like the facade of Notre Dame of Paris, he will understand the necessity for adopting particular arrangements in the great edifice, so as to oppose the greatly multiplied chances of settlements, ruptures, and consequently of a general dislocation. We have already seen how primitive Gothic constructors found a resource against settlements and deformations resulting from the use of stones on edge, to strengthen the highest piers, built in courses. We have also shown how during the Romanesque epoch, the constructors had enclosed a concrete within the facing of stone retaining externally the appearance of a structure of large blocks. The Gothic architects, having experienced the insufficiency of this procedure and i



its little cohesion, substituted masonry of small stones for concrete, and claimed to give it strength and especially stiffness by joining to this great isolated blocks of stone, only cemented at certain distances to the body of the structure by courses set on their beds and penetrating deeply into that structure. Stones set on edge compose the columns, bonding courses bases, rings, capitals, friezes and bands. This is the origin of these basement arcades, and those arrangements of little columns placed against the surfaces, and often of those perforated facings, ~~that decorate the heads of the external~~ flying buttresses or of walls. The facade of the cathedral of Paris supplies us with beautiful examples of this mixed construction, composed of courses and of facings set on edge, whose function is so frankly emphasized, and that presents such brilliant and ornamental motives. It is true that it is necessary to have been called to dissect these structures to recognize their practical sense; nothing is more simple in appearance as a structure, than the enormous facade of Notre Dame of Paris, and this is one of its qualities. In seeing such a mass, one cannot suppose it necessary to employ certain artifices, very labored combinations to give it perfect stability. It seems as if it would have sufficed to pile up courses of stone from base to ridge, and that this enormous mass must maintain itself by its own weight. But we repeat, that to erect a facade 65.6 ft. high or one of 19.0 ft. are two different operations, and the facade of 65.6 ft, perfectly stable and well combined could not maintain itself upright, if its dimensions were tripled in all directions. These are laws that practice alone can make known. It is unnecessary to make complex calculations to understand, for example, that a pier with a horizontal square section of 10.8 sq. ft., and whose height is 32.8 ft., gives 353. cu. ft., resting on a square surface 3.28 ft. side; that if we double the height of this pier, its thickness and width, although the ratio of its height and base are similar, to that of the first pier, we shall obtain a square area 6.6 ft. side, 43.2 sq. ft. area, and a volume of 796 cu. ft. In the first case the ratio of area to volume is 1 / 10; in the second 1 : 20. Thus the ratio of loads to the areas are in an increasing proportion as the scale of the edifice is enlarged.<sup>1</sup> This primary rule being established, in t



in the construction of very large edifices appears a difficulty, that still increases the effect of the loads produced by the increase of volume. If the materials do not exceed a certain height of quarry layer, their dimensions in length and width are likewise limited; it results from this, for example, that if one can erect a pier having an area of 10.8 sq. ft., in its horizontal section by means of courses, each of a single block of stone, it will not be the same when a pier will have 43.2 sq. ft. in horizontal section, for one cannot procure courses of that dimension. Thus in increasing the scale of an edifice, on the one hand is changed the ratio between the volumes or weights and areas, on the other one cannot obtain a complete homogeneity in the parts composing it. A new case of rupture and dislocation. To avoid the danger resulting from too great a load resting on too small an area, naturally one is led to increase this area at the base, free to diminish it as the structure rises, and the loads become comparatively less. The type most nearly approaching this principle is a pyramid; but a pyramid is a pile and not a structure.

Note 1.p.159. We have sometimes found architects very surprised to see the piers of their churches crush under the load, saying:-- "But we have followed exactly the relative proportions of such edifices, and have employed materials of like resistance; Gothic construction really offers no security." One might reply:-- "No security it is true, if one will increase or diminish the scale while retaining the relative proportions; Gothic construction demands that one takes time to study it, and to know its principles, and Gothic architects were wrong to invent a system of construction, which must be known and reasoned to be applied."

Assume a tower erected on four walls, in section this tower presents Fig. 90. We have given to the walls at the base a thickness sufficient to resist the pressure of the upper parts, and as much to reduce this pressure as not to pile up materials uselessly, we have successively reduced the thickness of those walls as our structure is elevated. But the entire load rests on the surface C D, and if the increase in strength D E F be not perfectly bonded, does not accurately combine with the load A B, the greatest settlement being from A to B, there will appear cracks, first at I, later at G; this increase



of strength D E F that we added will be more ingenious than a useful, and the entire weight then coming to effectively load the surface C D, the inner surface of the wall will be crushed. If our tower is very high, it will be easy to bond it perfectly, the external with the internal surfaces, by means of long stones, making a homogeneous masonry, and then the base C E will actually bear the entire load; but if our tower be very high, if its mass be colossal, whatever precautions we may take, the structure being composed of a considerable number of stones, we can never bond the two surfaces with sufficient accuracy as to resist that difference of pressure exerted at the interior and exterior, our masonry will have separated, and the effects just mentioned will be produced. It is then necessary to employ artifice. It is essential to act so that the external surface being less loaded must present a stiffness superior to the internal surface, and that at the recessions may be a very strong connection with the mass of the structure. In other terms, it is necessary for the external surface to shore the body of the masonry, and to produce the effect made apparent by Fig. 90 bis. Now that is not easy when one only has stones all being of nearly the same dimensions. Yet the architect of the facade of the cathedral of Paris attained that result by the very wise and well calculated combination of its construction. He commenced by establishing each tower, not on solid walls, but on piers (see plan of cathedral of Paris, Art. Cathedrale), for it is easier to give homogeneity to the construction of a pier than to that of a wall. These external and initial piers are built in courses of hard stone, regular and carefully leveled, enclosing excellent concrete composed of large stones set in a bed of mortar. The internal pier is abutted in all directions since it is internal, and it supports a vertical load; but the piers on the exterior, toward the place on the side, must have been shored by powerful footings. Now the entire construction is well faced with long stones inside and outside, and from the substructure to the base of the tower, the buttresses are built as indicated by Fig. 91.

It results from the method employed, that although there may have been a much greater pressure exerted on the internal surface (where the dotted line A B indicates the depth through



the jambs of the openings at different heights) than on the external surface of the buttresses, and that in consequence of that pressure, one can note a sensible settlement inside, all the loads are transferred by the arrangement of blocks of stone sunk in the thickness of the concrete, forming as indicated in Fig. 91 bis a superposition of angles like saw-teeth, so that the load C D rests on the base E F, load E G on base I K, load I L on base M N, and so on to the base of the buttress. But since in fact settlement must occur between the points E G, I L, M O, P R, it results from this that the projections G F, L K, O N, R S, come to bear very strongly on their angles F, K, N, S on the external surface V; since this surface is a smaller depression than the internal surface, because less loaded and fulfils the office of shoring, that we have indicated in Fig. 90 bis.

Now that we no longer erect these colossal structures composed of very different parts, we rarely suspect the effects manifested in such circumstances, and we are very much astonished when we see them occur, causing the most serious disorder. It is easy to reason theoretically on these enormous loads unequally distributed; but in practice for lack of precautions in detail, and learning the execution of routine methods, we are most frequently compelled to recognize our powerlessness, to blame the art that we profess, the soil on which we build, the materials, contractors, all and everybody, except the perfect ignorance in which it is desired to leave us, under the pretext of preserving classical traditions. We freely admit that the architecture of the Romans may be superior to Gothic architecture, and still more freely, that for us the architecture of the Greeks, Romans, and of the middle ages is good from the moment that it remains faithful to the principles accepted by each of these three civilizations; we shall not dispute on a matter of taste. But if we desire to erect monuments in imitation of those of antique Rome, it is necessary for us to build as the Romans built; having space, slaves, a powerful will; to be masters of the world, to seek men and take materials wherever it seems good to us. Louis XIV took the part of the Roman constructor seriously, even to pretend sometimes to build like a Roman. He commenced the aqueduct of Maintenon like a real emperor of the ancient city; he began



without the power to complete it. Money, men, and more than all that, imperious reason was lacking. In our great works of railways, we also approach the Romans, and this is what we have done best; but for urban structures, the monuments or habitations of our cities, when we pretend to imitate them, we are only ridiculous, and we should do more wisely, it seems to us, to profit by the elements employed among us with reason and success by generations of artists, who adopted principles in accord with our needs, means, materials and modern genius.

We have already said enough of the construction of the middle ages to make understood wherein its principle entirely differs in principle from Roman construction, how the procedures suited to one cannot suit the other, how the two methods are the result of civilizations, of opposed ideas and systems. Having accepted the principle of equilibrium, of forces acting and opposed to each other to attain stability, the constructors of the middle ages, because of the tendency natural to man to abuse everything, must come to exaggerate in the successive applications of these principles, what he could have of good, reasonable and ingenious. Still we repeat, abuse makes itself felt less in the provinces of the royal domain, and especially in Ile-de-France, than in the other provinces into which the system of Gothic construction had penetrated.

What is easily recognized, is that already at the middle of the 13th century, constructors made a sport of those questions of equilibrium so difficult to solve in edifices of very great dimensions and frequently composed of weak materials. In the North they built only in stone; but they employed simultaneously in the same edifice cut stone in courses, set on its quarry bed, large rubble flushed with mortar, a mass compressible at need, and blocks set on edge, rigid and inflexible struts, capable of great assistance in certain cases. Elasticity being the first of all conditions to be satisfied in monuments erected on slender supports, yet it was necessary to find besides this elasticity a rigidity and an absolute resistance. It is by the lack of having been able or having desired to apply this principle in all its rigor, that the cathedral of Beauvais could not maintain itself. There elasticity is everywhere. That monument may be compared to a wicker cage.



We shall soon return to it, for even its defects are excellent for instruction. Let us not leave so soon our cathedral of P Paris. The section of one of the buttresses of the towers sufficiently shows that the constructors of the beginning of the 13 th century did not pile stones on each other without foresight, and without taking into account the defects produced in such great edifices by the laws of gravity. Their masonry lives, acts, fulfils its function, and is never an inert and passive mass. Today we build our edifices somewhat as a sculptor makes a statue; provided that the human form is passably preserved, that suffices; it is no less an inorganic block. The Gothic edifice has its organs, and laws of equilibrium, and each of its parts concurs with the whole by an action or a resistance. Everyone cannot see the interiors of the buttresses of the towers of Notre Dame of Paris, and we foresee the objection, that has been sometimes made to us; that our imagination causes us to attribute to those artists of past centuries intentions, that they never had. Let us take for those defiant minds an example, which they can verify with the greatest ease in the same monument. The great vaults of the nave of the cathedral of Paris, as all can see, are composed of diagonal arches comprising two bays and crossed by a transverse arch; this is the primitive system of Gothic vaults developed at length in this Article. It results from this combination that the piers of the great nave are loaded unequally, since alternately they receive a transverse arch alone or a transverse arch and two diagonal arches, and still the piers of the great nave are all of equal diameter. There is something that shocks the reason, particularly in a very large edifice, since these unequal loads must produce unequal settlements, and if the piers receiving three arches are strong enough, those receiving but one are too strong; on the contrary, if those receiving only one arch are of proper diameter, those receiving three are too slender. Apparently there is nothing to object to that criticism, and we must confess that we were long in explaining to ourselves such an apparent forgetfulness of the simplest principles among artists always proceeding by reasoning.

Yet see what proves to us, that it is unnecessary to hasten to give judgment on an art, that one has hardly commenced to

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 arranged by reasoning.  
 The same may be said of the cathedral of Amiens, which is  
 a fine judgment on an art, that one has hardly conceived

unravel. Let us enter the side aisles of the cathedral, doubled in the nave as around the choir; but not in passing, that each aisle was built 15 or 20 years after the choir, and that the architects of the beginning of the 13<sup>th</sup> century, who built them profited by the faults committed by their predecessor. We observe that the piers separating the double side aisles of the nave are not all similar; in pairs we see alternately the cylindrical column composed of stone drums, and the central column likewise composed of drums, but surrounded by ten little columns set on end and each of a single piece. (See plan, Fig. 92). Why is that difference in construction? It is caprice or fancy? However little one has studied these monuments, he will remain convinced that caprice does not enter into the combinations of constructors of this epoch, particularly if this concerns an architectural member as important as a pier.<sup>1</sup> The question being stated, "why this difference?", with some attention we shall solve it soon. These intermediate piers A surrounded by little columns on end are in line with the columns of the great nave receiving the heaviest loads, i.e., a transverse and two diagonal arches. Now it is first necessary to know, that originally the flying buttresses of the nave were not those seen today, which date only from the second half of the 13<sup>th</sup> century. Those primitive flying buttresses were double span, i.e., they rested at first on an intermediate pier placed on the piers A B of the double side aisle, and they were abutted in their turn by secondary flying buttresses over the spaces A C, B D. (See Art. cathedrale, Fig. 2, giving the section of the nave of Notre Dame of Paris). Certainly the flying buttresses intended to abut the ends of the transverse and diagonal arches of the great vaults were stronger than those designed only to abut a single intermediate transverse scarcely loaded arch. Perhaps even the intermediate transverse arch of the great vaults was not abutted by a flying buttress, which would have prevented the vaults from retaining their curvature, since in the two transepts we still see single transverse arches, thus left to themselves, that are not deformed. The preceding explanations contained in this Article have shown that the vertical pier supporting vaults only plays a secondary part, and that a great part of the weight of the vaults supported by the flying buttresses



rests on the abutments of these flying buttresses. Then it would be reasonable to give to the piers intended to support the piers on which rest the flying buttresses, or at least flying buttresses more powerful than the others, a greater resistance. But if the architect had given a little greater diameter to the piers A than to the piers B (Fig. 92), then these piers would still have been compressed by the very great load they must support, and their settlements would have occasioned very serious disorder in the upper works, the rupture of the flying buttresses, and consequently the deformation of the great vaults. Still the architect did not wish to give those piers A a diameter such, that they would have made the construction of the vaults of the side aisle difficult, and produced a very ungraceful effect; then as always, he used artifice, he surrounded his cylindrical piers, built in courses, by little columns set on end, he enclosed the drums by ten strong and incompressible struts (93), certain that this system of construction could suffer neither settlement nor deformation, and that consequently very strong flying buttresses weighing on these piers could suffer no deflection. This arrangement had also the advantage of leaving above the capitals, between the transverse and diagonal arches, a strong course resting directly on the central column. (Fig. 9).

Note 1.p.165. Caprice is one of these explanations accepted in many cases, when one speaks of Gothic architecture; it has the advantage of reassuring the minds of persons, who love better to cut by one word a difficult question, than to attempt to solve it.

The method consisting in employing the materials (stone) either on bed or on edge was rapidly perfected during the first half of the 13th century. There is indeed a resource, to which we, who desire to claim to have invented everything, have recourse daily, since we use cast iron in our structures with much less intelligence, let us say, than did Gothic constructors, when they sought to obtain incompressible and rigid points of support by employing certain stones of excellent quality.

Let us examine other applications even better reasoned still on these principles. The choir of the cathedral of Amiens, built some years before that of Beauvais, from the point of view of Gothic construction is a masterpiece, particularly in

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... directly on the ...  
... it has  
... of ... it has  
... of ...  
... by one word a difficult question. Then to ...  
...  
... consisting in ... (stone)  
... on ... was ...  
... in ... There is indeed a ...  
... to have ...  
... since we ...  
...  
... by ...  
... even ...  
... The ... of ...  
... some years before that of ...  
... is a ...

the lower works.<sup>1</sup> Let us first examine the piers of the sanctuary of Notre Dame of Amiens. These piers give in plan a great cylindrical column having 3.94 ft. diameter with four engaged columns, three with diameters of 1.45 and one with a diameter of 1.15 ft. These four columns are only engaged one fourth in the middle column. The abacuses of the capitals are traced to exactly receive the arches of the vaults, as appears in Fig. 94, and the sections of these arches are themselves cut according to their functions. The archivolts A are composed of a double series of voussoirs, they support the wall. The transverse arches B of the side aisles, which only support the vault and stay the construction, have a more slender profile, and all their resistance presents itself at one side like a rib. The diagonal arches C are moulded on the same principle, but finer than the transverse arch, and the load they support being lighter and their function less important. A single impost block, the first one D, has its upper bed horizontal; above this impost block each separates and forms voussoirs independent of each other. One will observe that the triangles E of the fillings of the vaults rise vertically to the point where their meeting with the extrados of the second arch F, having the function of the side arch, permits them to follow its curve. Assume a horizontal section of that construction at the level P and we obtain Fig. 95, on which we have traced by white and dotted lines the construction of the combination of the alternate jointing of the courses. At S is a mass solidly built and not concrete, but by means of superposed horizontal courses supporting the overhang of the buttress of the upper gallery; If we cut the pier vertically in its axis M N, we find this construction (96). A is the level of the capitals at the springing of the vaults of the side aisle; B is the impost of these vaults with its temporary tie R, placed only during construction, so as to prevent the bending of the pier and to arrest the thrust of the lateral arches until these piers are loaded (Art. Chânage), C is the transverse arch, which is free; D are corbelled courses receiving the buttress E of the gallery of the second story. This buttress is composed of large blocks of stone set on edge, and is connected to the main pier I by an intermediate lintel F. At G is the course forming the covering of the gallery, the upper

lowest number. Let us first examine the case of a single  
line of three lines of America. These three lines in plan a tri-  
angular network having 7, 12, 13, and 14 lines.  
Let column, where the columns are 1, 2, 3, and 4, and the  
number of lines in each column are 7, 12, 13, and 14.  
There is one middle column. The spaces of the columns are  
not as strictly receive the spaces of the columns, as shown  
in fig. 10, and the sections of these spaces are character-  
istic according to their functions. The spaces are a series  
of a double series of vases, they appear as well.  
The spaces are 8 of the side angles, which only spaces  
the vases and stay the construction, have a more slender  
outline, and all their resistance presents itself as one line  
in a line. The diagonal spaces 9 are worked on the same or-  
der, but finer than the transverse ones, and the load they  
carry being lighter and their function less important.  
Of the lateral block, the first one 6, and the second one 7, are  
only three lines in each block, and they are  
the continuation of each other. One will observe that the  
spaces 8 of the angles of the vases are vertically to  
the spaces 9, their meaning with the extension of the spaces  
in 7, making the function of the side angles, which are to  
align the curve. Assume a horizontal section of that con-  
struction at the level 5, and we shall find 12, 13, and 14 lines  
in each block and dotted lines the construction of the con-  
struction of the alternate joining of the courses. At 5 is a  
line which is not continuous, but by means of an inter-  
mediate column supported the weight of the courses  
of the upper gallery; if we cut the pier vertically in two  
the V, 6, finding this construction (9d). A is the level of  
the section at the section of the section of the side angles,  
in the midst of these vases with its symmetry the 8, 9, 10,  
at this being construction, so as to prevent the bending of  
the pier and to extend the space of the courses.  
The pier are loaded (Art. Chaisse), 9 is the transverse  
pier, which is 12, 13, and 14 are vertical courses transverse to  
the 8 of the gallery of the second story. This pier  
is composed of three lines of vases and the pier, and the  
pier on the side 7 by an intermediate pier 12, 13, and 14  
the pier formed the covering of the gallery, the pier

passage at the level of the sills of the upper windows and tie. At H is the isolated column composed of large pieces of stone like the buttress and consequently rigid, that receives the head of the flying buttress. The entire load is thus transferred to the pier I, first because on that pier spring the arches of the vaults, then because the buttress E as well as the column H, being composed of stones set on edge, the settlement and the load consequently come on that pier I. That load being much greater than that resting on the buttress E, it results that the corbelled courses E completely destroy the tip or overhang of the buttress E. The transverse arch C is free; it cannot be deformed by the pressure of the pier E, since that does not act on its haunch. This construction is very simple; yet it was necessary to invent it; but here is what indicates the extraordinary sagacity of the masters of the work of this so remarkable a part of the cathedral of Amiens. The side aisles of the radiating chapels of the apse of that edifice give in that plan above the bases, Fig. 97. The flying buttresses that abut the thrust of the upper vaults have a double span, i.e., they rest on a first pier placed on the group A of columns, and on a second pier placed on the abutment B. In section on C B, these flying buttresses present the profile (98). This section clearly shows, that if the load resting on the piers C is considerable, that on the piers A is still greater, because it is active, produced not only by the weight of the buttress D, but also by the pressure of the flying buttress. Every structure composed of courses settles, and this settlement is the more pronounced the greater the load. A settlement produced in the pier C would have no danger if the piers A settled less, for on examining the sections in Fig. 98, one will see, that the settlement of an inch or so in the pier C, if the pier A resists, would only have the effect of pressing the flying buttress more against the haunches of the upper vaults and holding together the structure more powerfully by pressing it toward the interior, since it is polygonal in plan; but it is necessary that the pier A does not settle as much as the pier C. The entire resistance of the construction is subject to that condition. Now see how the constructors have solved this problem. The piers C were built with courses separated by beds of thick mortar, according to the method of



the masons of that epoch; on the contrary the piers are composed of clusters of columns built of large blocks of stone, a sort of struts (to use a term of carpentry), that cannot settle like numerous courses set on beds of mortar. Not wishing to give these piers A a wide bearing, so as not to encumber the entrance of the chapels, it was the best means to render them rigid under the load that they must support, to compose them of a cluster of columns nearly monolithic, and thus diminishing the number of joints, to avoid all cause of settlement. Observe that the materials at command of the architects of Picardy could be set on edge with impunity, and that if they had built the piers A of several blocks, that is because they could not procure monoliths 32.8 ft. high; they have taken the largest stones that they could find, varying from 3.3 to 7.6 ft., while the piers C are composed of courses 1.6 to 2.0 ft. high.

Note 1. p.167. See in Art. Cathedrale the historical summary of the construction of Notre Dame of Amiens. The upper parts of the choir could only be completed with insufficient resources.

At Amiens theory and practice were right in the difficulties presented by the erection of a nave 49.2 ft. between axes of piers with 139.4 ft. beneath the crown, flanked by side aisles 23.0 ft. inside by 48.3 ft. high to the crown. This vast structure has retained its bearing, and the movements necessarily produced in such an extensive structure have not changed its stability. Then the architects renounced cross vaults comprising two bays (hexabartite); desiring to distribute the thrusts equally to the points of support separating these bays, they adopted after 1220 rectangular cross vaults according to the plan (99); this was more logical; the piers A M I H were alike and the buttresses B also similar, the flying buttresses have the same strength. The constructors changed formulas; their artistic feeling must have been shocked by those cross vaults on double bays appearing to transfer the loads to alternate piers, and whose diagonal arches C D by their inclination masked the windows opened at C'E beneath the side arches. Further as we have stated before, these diagonal arches on a very long diameter C D compared to the diameters of the transverse arches C F, obliged them to raise the crowns G much, which interfered with placing the tiebeams of the carpentry, 1681-

... of the ... on the contrary the ... are ...  
 ... of ... of ... of ... of ...  
 ... (the use of ...), that ...  
 ...  
 ... A wide bearing, so as not to encounter  
 ...  
 ... the fact that they must support, to compose  
 ... of columns nearly monolithic, and thus dis-  
 ... the number of joints, to avoid all cause of settling  
 ... the materials at ... of the ...  
 ... be set on edge with impunity, and that it is  
 ... of several blocks, each is ...  
 ...  
 ... stones that they would find, varying from 3.8  
 ... while the ... is composed of courses 1.6 to

... the historical ...  
 ... of ... the upper part

... theory and practice were right in the ...  
 ... of a ... between ...  
 ... 1.24 ft. beneath the crown, ... by side ...  
 ... by 42.8 ft. ... the crown. This ...  
 ... has retained its bearing, and the movement neces-  
 ... in such an extensive structure have not ...  
 ... Then the architect renounced cross vaults con-  
 ... (nephartite); desiring to distribute the ...  
 ... to the points of support separating these ...  
 ... after 1210 rectangular cross vaults according to  
 ...; this was more logical; the ... A ... were

... The construction changed ...  
 ... have been ... by these cross ...  
 ... to ... the ...  
 ... and whose ... by their inclination  
 ... the windows opened at ... beneath the side ...  
 ...  
 ... the ... of the ...  
 ... to raise the crown ...  
 ... with ... the ...

or required a considerable height of the eave walls above the side arches C E. In turning the cross vaults by bays, the diagonal arches A H being round, it was easy to arrange that the crowns L of these arches should not be above the level of the crowns of the transverse arches A I, M H, that were pointed.

Our readers know enough now, we believe, to understand in its entirety as well as in its details, the construction of a great church of the 13 th century, for example such as the cathedral of Beauvais. To avoid repetition and to summarize the scattered methods of which we have given an idea, we are going to follow step by step one of those great structures from the foundations to the carpentry of the roofs. If we select the cathedral of Beauvais, this is not because that edifice is perfect in execution, but because it is the truest and most absolute expression of the theory of the constructor about the middle of the 13 th century. This edifice partly fell less than a century after the completion of the choir; yet it was conceived in a fashion to be able to remain standing for centuries. The catastrophe that completely changed its character was caused by poor execution, the lack of rigid points or their too weak resistance, and especially by the nature of the materials, which were neither sufficiently large nor solid enough. If the architect of the choir of Beauvais had possessed the materials of Burgundy, those employed at Dijon and Semur, for example, the fine limestones of Chatillon-sur-Seine, or again the stone of Montbard, Anstrude or Dornecy, or even what would have been possible, the stones of Laversine, Crouy, and certain hard layers of the basins of the Oise or Aisne, the choir of Beauvais would remain standing. The master of works of Beauvais was a man of genius, who desired to reach the limits of the possible in stone construction; his calculations were correct, his combinations profoundly sagacious, his conception admirable, he was badly seconded by the workmen, and the materials placed at his disposal were insufficient. His work is no less the subject of very precious studies, since it supplies us with the means of knowing the results to which the system of construction of the 13 th century could attain. We have given in Art. Cathedrale, Fig. 22, the plan of the choir of Beauvais. This plan, if compared to that of the cathedral of Amiens, shows that the two parallel

and a considerable height of the walls above the  
 level of the ground. In turning the cross walls by hand, the dis-  
 tance between the cross walls was found to be  
 about 1.5 m. It was found that the level of the  
 ground of these arches should not be above the level of the  
 ground of the transverse arches A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, AA, AB, AC, AD, AE, AF, AG, AH, AI, AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE, BF, BG, BH, BI, BJ, BK, BL, BM, BN, BO, BP, BQ, BR, BS, BT, BU, BV, BW, BX, BY, BZ, CA, CB, CC, CD, CE, CF, CG, CH, CI, CJ, CK, CL, CM, CN, CO, CP, CQ, CR, CS, CT, CU, CV, CW, CX, CY, CZ, DA, DB, DC, DD, DE, DF, DG, DH, DI, DJ, DK, DL, DM, DN, DO, DP, DQ, DR, DS, DT, DU, DV, DW, DX, DY, DZ, EA, EB, EC, ED, EE, EF, EG, EH, EI, EJ, EK, EL, EM, EN, EO, EP, EQ, ER, ES, ET, EU, EV, EW, EX, EY, EZ, FA, FB, FC, FD, FE, FF, FG, FH, FI, FJ, FK, FL, FM, FN, FO, FP, FQ, FR, FS, FT, FU, FV, FW, FX, FY, FZ, GA, GB, GC, GD, GE, GF, GG, GH, GI, GJ, GK, GL, GM, GN, GO, GP, GQ, GR, GS, GT, GU, GV, GW, GX, GY, GZ, HA, HB, HC, HD, HE, HF, HG, HH, HI, HJ, HK, HL, HM, HN, HO, HP, HQ, HR, HS, HT, HU, HV, HW, HX, HY, HZ, IA, IB, IC, ID, IE, IF, IG, IH, II, IJ, IK, IL, IM, IN, IO, IP, IQ, IR, IS, IT, IU, IV, IW, IX, IY, IZ, JA, JB, JC, JD, JE, JF, JG, JH, JI, JJ, JK, JL, JM, JN, JO, JP, JQ, JR, JS, JT, JU, JV, JW, JX, JY, JZ, KA, KB, KC, KD, KE, KF, KG, KH, KI, KJ, KK, KL, KM, KN, KO, KP, KQ, KR, KS, KT, KU, KV, KW, KX, KY, KZ, LA, LB, LC, LD, LE, LF, LG, LH, LI, LJ, LK, LL, LM, LN, LO, LP, LQ, LR, LS, LT, LU, LV, LW, LX, LY, LZ, MA, MB, MC, MD, ME, MF, MG, MH, MI, MJ, MK, ML, MM, MN, MO, MP, MQ, MR, MS, MT, MU, MV, MW, MX, MY, MZ, NA, NB, NC, ND, NE, NF, NG, NH, NI, NJ, NK, NL, NM, NN, NO, NP, NQ, NR, NS, NT, NU, NV, NW, NX, NY, NZ, OA, OB, OC, OD, OE, OF, OG, OH, OI, OJ, OK, OL, OM, ON, OO, OP, OQ, OR, OS, OT, OU, OV, OW, OX, OY, OZ, PA, PB, PC, PD, PE, PF, PG, PH, PI, PJ, PK, PL, PM, PN, PO, PP, PQ, PR, PS, PT, PU, PV, PW, PX, PY, PZ, QA, QB, QC, QD, QE, QF, QG, QH, QI, QJ, QK, QL, QM, QN, QO, QP, QQ, QR, QS, QT, QU, QV, QW, QX, QY, QZ, RA, RB, RC, RD, RE, RF, RG, RH, RI, RJ, RK, RL, RM, RN, RO, RP, RQ, RR, RS, RT, RU, RV, RW, RX, RY, RZ, SA, SB, SC, SD, SE, SF, SG, SH, SI, SJ, SK, SL, SM, SN, SO, SP, SQ, SR, SS, ST, SU, SV, SW, SX, SY, SZ, TA, TB, TC, TD, TE, TF, TG, TH, TI, TJ, TK, TL, TM, TN, TO, TP, TQ, TR, TS, TT, TU, TV, TW, TX, TY, TZ, UA, UB, UC, UD, UE, UF, UG, UH, UI, UJ, UK, UL, UM, UN, UO, UP, UQ, UR, US, UT, UY, UZ, VA, VB, VC, VD, VE, VF, VG, VH, VI, VJ, VK, VL, VM, VN, VO, VP, VQ, VR, VS, VT, VU, VV, VW, VX, VY, VZ, WA, WB, WC, WD, WE, WF, WG, WH, WI, WJ, WK, WL, WM, WN, WO, WP, WQ, WR, WS, WT, WU, WV, WW, WX, WY, WZ, XA, XB, XC, XD, XE, XF, XG, XH, XI, XJ, XK, XL, XM, XN, XO, XP, XQ, XR, XS, XT, XU, XV, XW, XX, XY, XZ, YA, YB, YC, YD, YE, YF, YG, YH, YI, YJ, YK, YL, YM, YN, YO, YP, YQ, YR, YS, YT, YU, YV, YW, YX, YY, YZ, ZA, ZB, ZC, ZD, ZE, ZF, ZG, ZH, ZI, ZJ, ZK, ZL, ZM, ZN, ZO, ZP, ZQ, ZR, ZS, ZT, ZU, ZV, ZW, ZX, ZY, ZZ, AA, AB, AC, AD, AE, AF, AG, AH, AI, AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE, BF, BG, BH, BI, BJ, BK, BL, BM, BN, BO, BP, BQ, BR, BS, BT, BU, BV, BW, BX, BY, BZ, CA, CB, CC, CD, CE, CF, CG, CH, CI, CJ, CK, CL, CM, CN, CO, CP, CQ, CR, CS, CT, CU, CV, CW, CX, CY, CZ, DA, DB, DC, DD, DE, DF, DG, DH, DI, DJ, DK, DL, DM, DN, DO, DP, DQ, DR, DS, DT, DU, DV, DW, DX, DY, DZ, EA, EB, EC, ED, EE, EF, EG, EH, EI, EJ, EK, EL, EM, EN, EO, EP, EQ, ER, ES, ET, EU, EV, EW, EX, EY, EZ, FA, FB, FC, FD, FE, FF, FG, FH, FI, FJ, FK, FL, FM, FN, FO, FP, FQ, FR, FS, FT, FU, FV, FW, FX, FY, FZ, GA, GB, GC, GD, GE, GF, GG, GH, GI, GJ, GK, GL, GM, GN, GO, GP, GQ, GR, GS, GT, GU, GV, GW, GX, GY, GZ, HA, HB, HC, HD, HE, HF, HG, HH, HI, HJ, HK, HL, HM, HN, HO, HP, HQ, HR, HS, HT, HU, HV, HW, HX, HY, HZ, IA, IB, IC, ID, IE, IF, IG, IH, II, IJ, IK, IL, IM, IN, IO, IP, IQ, IR, IS, IT, IU, IV, IW, IX, IY, IZ, JA, JB, JC, JD, JE, JF, JG, JH, JI, JJ, JK, JL, JM, JN, JO, JP, JQ, JR, JS, JT, JU, JV, JW, JX, JY, JZ, KA, KB, KC, KD, KE, KF, KG, KH, KI, KJ, KK, KL, KM, KN, KO, KP, KQ, KR, KS, KT, KU, KV, KW, KX, KY, KZ, LA, LB, LC, LD, LE, LF, LG, LH, LI, LJ, LK, LL, LM, LN, LO, LP, LQ, LR, LS, LT, LU, LV, LW, LX, LY, LZ, MA, MB, MC, MD, ME, MF, MG, MH, MI, MJ, MK, ML, MM, MN, MO, MP, MQ, MR, MS, MT, MU, MV, MW, MX, MY, MZ, NA, NB, NC, ND, NE, NF, NG, NH, NI, NJ, NK, NL, NM, NN, NO, NP, NQ, NR, NS, NT, NU, NV, NW, NX, NY, NZ, OA, OB, OC, OD, OE, OF, OG, OH, OI, OJ, OK, OL, OM, ON, OO, OP, OQ, OR, OS, OT, OU, OV, OW, OX, OY, OZ, PA, PB, PC, PD, PE, PF, PG, PH, PI, PJ, PK, PL, PM, PN, PO, PP, PQ, PR, PS, PT, PU, PV, PW, PX, PY, PZ, QA, QB, QC, QD, QE, QF, QG, QH, QI, QJ, QK, QL, QM, QN, QO, QP, QQ, QR, QS, QT, QU, QV, QW, QX, QY, QZ, RA, RB, RC, RD, RE, RF, RG, RH, RI, RJ, RK, RL, RM, RN, RO, RP, RQ, RR, RS, RT, RU, RV, RW, RX, RY, RZ, SA, SB, SC, SD, SE, SF, SG, SH, SI, SJ, SK, SL, SM, SN, SO, SP, SQ, SR, SS, ST, SU, SV, SW, SX, SY, SZ, TA, TB, TC, TD, TE, TF, TG, TH, TI, TJ, TK, TL, TM, TN, TO, TP, TQ, TR, TS, TT, TU, TV, TW, TX, TY, TZ, UA, UB, UC, UD, UE, UF, UG, UH, UI, UJ, UK, UL, UM, UN, UO, UP, UQ, UR, US, UT, UY, UZ, VA, VB, VC, VD, VE, VF, VG, VH, VI, VJ, VK, VL, VM, VN, VO, VP, VQ, VR, VS, VT, VU, VV, VW, VX, VY, VZ, WA, WB, WC, WD, WE, WF, WG, WH, WI, WJ, WK, WL, WM, WN, WO, WP, WQ, WR, WS, WT, WU, WV, WW, WX, WY, WZ, XA, XB, XC, XD, XE, XF, XG, XH, XI, XJ, XK, XL, XM, XN, XO, XP, XQ, XR, XS, XT, XU, XV, XW, XX, XY, XZ, YA, YB, YC, YD, YE, YF, YG, YH, YI, YJ, YK, YL, YM, YN, YO, YP, YQ, YR, YS, YT, YU, YV, YW, YX, YY, YZ, ZA, ZB, ZC, ZD, ZE, ZF, ZG, ZH, ZI, ZJ, ZK, ZL, ZM, ZN, ZO, ZP, ZQ, ZR, ZS, ZT, ZU, ZV, ZW, ZX, ZY, ZZ.

bays adjoining the piers of the crossing are narrower than the next two; the constructor thus avoided too active thrusts on the two piers of the transverse aisle forming the entrance of the choir. As for the succeeding bays, they have an unusual width (nearly 29.5 fta between the axes of the piers). The need of giving free spaces is so evident at Beauvais, that the piers of the semicircle do not have little engaged columns at their sides to receive the archivolts, but only radially to receive the ribs of the greater vaults, the transverse and diagonal arches of the side aisle. According to the method of the constructors of that epoch, when they were not turned aside from their theories by questions of economy, the foundation of the choir is admirably built. The chapels rest on a solid circular mass faced with cut stone, as at the cathedral of Amiens, presenting externally a strong footing also faced with well dressed ashlar set in a bed of mortar. This wall of solid masonry is connected with the wall that supports the isolated piers by radiating underground walls.

At the cathedral of Amiens, where we have been able to examine the foundation down to the good ground, we found outside the profile (100). At A is a layer of brick earth 1.2 ft. thick laid on the virgin clay; at B is a bed of concrete 1.3 ft. thick; then from C to D are 14 courses of 1.0 to 1.3 ft. thickness each, of ashlar from the quarries of Blavelincourt near Amiens. This stone is a chalk full of lints, very strong, that is quarried in large blocks. Above is found a course E in stone from Croissy, then three courses of sandstone below the external ground. Above the external soil the entire edifice rests on six other courses of sandstone well surfaced and of extreme hardness. Behind the facings of the foundation is a concrete of large fragments of flint, of stone from Blavelincourt and Croissy, embedded in a very hard and well made mortar. On this artificial rock rests the immense cathedral. At Notre Dame of Paris, the foundations are likewise built with the greatest care, the whole resting on good ground, i. e., on the lower sand of the Seine, which is coarse and greenish. As for the piling claimed to exist beneath the masonry of most of our great cathedrals, we have never found traces of it.<sup>1</sup>

Note 1.p.177. It is with these piles of Notre Dame of Paris,



of Notre Dame of Amiens, with so many other fables, repeated for centuries concerning the construction of Gothic edifices. It would not be possible to construct a great cathedral on piles. These edifices could only be founded on broad footings; the points being very unequal in elevation, the first condition of stability was to find a perfectly homogeneous and resistant mass below the ground.

Not let us return to Notre Dame of Beauvais. We have given in Art. Arc-Boutant, Fig. 61, the entirety of the system adopted for the construction of the flying buttresses of the apse of the cathedral of Beauvais. It is necessary to return to the details of that construction, one will see how the architect of this choir attempted to excel the work of his colleague at Amiens. Yet these two apses were built at the same time, that of Beauvais being perhaps later by some years. We assume, as we have just done for a flying buttress of the choir of Notre Dame of Amiens, a section made through the axes of the piers of the apse of Beauvais (101). It is interesting to place in parallel these two sections, so we give this at the same scale. At Amiens the piers of the sanctuary are 45.9 ft. high from the pavement of the side aisle to the abacus of the capitals receiving the arches of the vaults of the side aisles; at Beauvais the same piers are 52.2 ft. high. But at Amiens the apsidal chables have the entire height of the side aisle, while at Beauvais they are much lower, and between the terrace covering them and the vaults of this side aisle exists a gallery, a triforium F. At Amiens the intermediate pier possesses a passive resistance, rigid, due to its mass and to the system of construction of the lower piers, as we have just demonstrated; the second pier is only an extra for safety, an excess of precaution, though necessary. At Beauvais the master of the work claimed to give this intermediate pier an active and real resistance, and to transfer to the second and external pier that passive resistance, that it is always necessary to find somewhere. He thought to be able thus to obtain more lightness in the entirety of his construction, more height and more stability. As we have just stated, the piers E of the sanctuary have more space and are thicker than those of Amiens in the direction of the thrusts. The cluster of little columns supporting the diagonal and side arches of the high



vaults are corbelled out on the lower capital G. The bearing H I is then greater, and the buttress K of the great triforium rests vertically on the lower pier. On this buttress of the triforium, it is no longer a single column that rises, as at Amiens, to receive the head of the flying buttress; these are two little twin columns set on end, as shown by the horizontal section A' made at A B. These little twin columns relieve the lintel L, that was a course forming the ceiling. Two other little columns were placed between this lintel course and the head of the first flying buttress, whose head rests against an enormous block of stone M, loaded by a cornice course and a pedestal H supporting a colossal statue. Two little twin columns are again set before that statue, between the first and second flying buttresses. These last small columns do not bear the head of this flying buttress, but a pinnacle whose form and construction we shall soon indicate. This entirety recalls nearly what we have seen at Amiens. But we observe that all this system of double construction rests vertically over the lower pier, the internal portion being built in courses and the external one in great rigid blocks set on edge, so as to stiffen that entirety, so slender and high;<sup>1</sup> we again observe that the very strong lintel L, the block M and its load N, evidently tend to add a considerable weight at the top of the lower struts to maintain it in the vertical, and to make quite real its function of a strut. Here is the internal pier made as rigid as possible, it now acts to resist the thrust of the vault exerted at a great height. The architect did not think himself satisfied by a single flying buttress as at Amiens, were it surmounted by rigid tracery; he was right for at Amiens in the parallel parts of the choir, that received three vault ribs instead of but one, these flying buttresses with tracery were raised by the pressure of the vaults, and in the 15 th century it was necessary to turn new flying buttresses beneath those of the 13 th. But see how the master of works at Beauvais made proof of a boldness without example, and at the same time of a rare sagacity. One sees that the intermediate pier O does not stand vertically over the pier P at the head of the chapel, as at the cathedral of Amiens, but its axis is vertically over the internal surface of that pier P. let us at once say that this pier O, whose



horizontal section C D is given at C', transmits more weight toward its surface C than to that at D. Its centre of gravity is then within the dotted line R, i.e., on the pier P. Still this pier is thus in equilibrium, tending rather to incline toward the interior than toward the great external buttress, then by its position it comes- 1, to support the thrust of the two flying buttresses; 2, to add to the resistance offered by these flying buttresses and tendency to incline toward the choir. The vertical pier O thus has the function of an oblique shore. If this active resistance does not suffice (and it could not suffice), the pier O is maintained in its turn in its function by the two last flying buttresses S T and the great passive buttress. But it may perhaps be objected, why that intermediate pier? It is because the great external buttress could not abut the thrust of flying buttresses of such great radius unless doubled, and that due to the intermediate buttress O, it only has to abut a diffused pressure, almost nothing.

Note 1.p.119. In the 14<sup>th</sup> century the little columns set on the triforium being broken were replaced by a solid pier (Art. Arc-boutant, Fig. 61), but one can now recognize their position and nearly their dimensions.

To clearly explain the function of the pier O, assume that we have to shore the choir of Beauvais; assume that we have for making this shore only the great buttress; if (101 bis) we place our shores as indicated at A, we shall certainly overturn the buttress C; but if inside that buttress C we place an intermediate shore D E, as in the sketch B, slightly inclined toward the choir, but kept in a vertical plane passing through the axes of the piers on the radius of the sanctuary, and that from that shore we place two shores G against the vault, then two other shores H I, we shall no longer have to fear the effect of the thrust of the vault V on the great buttress C, for the intermediate shore D E will sustain a great part of the thrust of the two shores F G, and transfer it to its base D. There is the entire problem set, and which has been solved by the architect of the choir of Notre Dame of Beauvais. Unfortunately the execution is defective. Yet it is certain that this enormous edifice would have retained perfect stability, if the architect had made the little twin columns above the triforium stronger and more resistant, for example,



if he could have made them of cast iron. The disorders that have manifested themselves in the construction have all come from that; These little columns were too slender and have broken, for they could not resist the load brought on them when the internal piers came to settle because of the drying of the mortar. Breaking, the lintels I broke (Fig. 101), the great blocks M tilted, resting too heavily on the head of the flying buttress, that was deformed, and the vault following the movement, the pressure on these flying buttresses was such, that they nearly all bent, their effect became nothing, because the upper flying buttress loosened slightly, since the vault no longer pressed against it. Equilibrium was destroyed; it was necessary to do considerable work to prevent an entire fall of the edifice. Fig. 101 ter giving in perspective the tops of this buttress receiving the head of the flying buttress, shows us very well the intention of the master of works was to obtain by the piers of the choir of the cathedral of Beauvais and under the flying buttresses, buttresses open but perfectly rigid, so as; 1, to load as little as possible the lower piers; 2, to cause that the settlements of the internal parts built in courses, stiffened by little columns set on end, should naturally transfer the loads inward. From this example and from those pertaining to Gothic construction, properly so-called, proceeds this principle, viz:- that every structure erected by means of superposed courses in great number should be stayed, stiffened by the addition of monolithic enclosing, flanking and staying the piers composed of superposed stones. This principle was scarcely applied by the Romans, who had no need to resort to it, it belongs to the Gothic constructors. Of this principle, they made one of the most common motives of decoration of edifices, and indeed it lends itself to the most brilliant and boldest combinations.

Certainly there are grave defects in the example of construction just given to our readers, and we do not conceal them. This external scaffolding of stone, that forms the entire strength of the building, is subject to storms; it seems that the constructor, instead of protecting the essential organs of his monument, took pleasure in exposing them to all chances of destruction. His system of equilibrium depends on the absolute resistance of materials too frequently imperfect. He



evidently desired to astonish, and he sacrificed all to that desire. But beside such serious defects, what thorough knowledge of the laws of equilibrium! What subjection of matter to the idea, what a theory fertile in applications! Do not imitate these subtle constructions, but let us boldly profit by so much acquired knowledge. To profit by it, it is at least necessary to cultivate and practise it.

In Art. Chainage we have indicated what were the procedures employed to tie together edifices in the middle ages. For the longitudinal timbers used during the Romanesque epoch, the constructors of the 13<sup>th</sup> century, perceiving that these quickly decayed, substituted iron cramps connecting the stones forming the courses. However this method was only employed in Ile-de-France with a singular exaggeration. There are some monuments like the S. Chapelle of the Palace at Paris, where all the courses from bottom to top are cramped together. Even at Notre Dame of Paris, it was perceived that all the constructions erected or repaired after the first years of the 13<sup>th</sup> century, at heights quite close, were connected by cramps cast in lead. Certainly those constructors did not have entire confidence in their methods so ingenious, and their natural good sense made them already feel, that they pushed this boldness too far. The manner in which they arranged these ties further shows well, what they feared most was the bending or twisting of the piers and walls, and that in that the system of stone struts adopted by the Burgundian architects had a marked superiority over the dangerous use of iron cramps sealed in solid stones. It must be said also, that the constructors of Ile-de-France procured long stones with difficulty, while in Burgundy they were common and of excellent quality.

It is now time to entertain our readers by an edifice, which in itself summarizes, while exaggerating them with great skill, all the theories of constructors of the Gothic school. We wish to speak of church S. Urbain of Troyes. In 1261 Jacques Pantaleon, a native of Troyes, was elected Pope under the name of Urban IV at Viterbo; he died in 1264. During his pontificate, he desired to erect at Troyes a church under the name of S. Urbain; this monument was commenced and rapidly erected, yet it remained unfinished, the successor of Urban probably not having regarded it best to continue the work of



his predecessor. Such as it is, the church of S. Urbain at Troyes indicates in the master of works charged with its erection a singular boldness, and the science of a constructor suited to astonish one. If the date of the foundation of church S. Urbain and that of the interruption of the works were not historical facts of incontestable authority, one would be tempted to assume that this edifice was erected about the beginning of the 14 th century. For ourselves, before proofs so little to be discussed, we long hesitated before believing that the 13 th century saw the commencement and completion of what exists of that monument; having the custom of trusting entirely to archaeological signs, we could not give to the construction of S. Urbain a date before the 14 th century, but a profound study of the construction caused us to see that the historical tradition was in accord with the fact. Men did not build thus in the 14 th century. Only the architect of S. Urbain was one of those artists in whom the most advanced principles and theory are allied to profound experience, to a practice never at fault, to a sure knowledge of the properties of materials, to infinite resources in execution and natural originality; in brief, he was a man of genius. His name is unknown to us like most of those laborious artists, if Pope Urban IV sent from Italy an architect to build his church at Troyes, we certainly should know it, but we should then not have to enlarge much on his work, for southern Italy then only erected edifices, that scarcely furnished types suited to be studied.

The play of S. Urbain of Troyes is from Champagne. The choir recalls that of the little church of Rieux, that we have just given; on the four piers of the crossing should rise a tower, probably very high, if we examine the large sections of the piers. Two other towers flank the entrance, accompanied by a projecting porch like that of S. Nicaise of Rheims. The central tower was never commenced, the nave and facade remaining unfinished. One can however by what remains of these parts render an accurate account of what this should have been. The choir and transepts are complete. Let us first cast the eyes on the plan of church S. Urbain (102), taken at the level of the ground story; this entirety is necessary to appreciate the different parts of its construction. This plan

The first of these is the fact that the plan of the building is not a simple rectangle, but a more complex shape, with a central tower and two side wings. This is a feature which is not found in the other buildings of the same type. The second is the fact that the plan of the building is not a simple rectangle, but a more complex shape, with a central tower and two side wings. This is a feature which is not found in the other buildings of the same type. The third is the fact that the plan of the building is not a simple rectangle, but a more complex shape, with a central tower and two side wings. This is a feature which is not found in the other buildings of the same type.

presents solid points of support, thick and resistant, a very simple general arrangement. Planted between two streets, two deep porches, well sheltered entrances into the two transepts. Above the ground story at the height of 10.8 ft., the entire structure presents only a glazed lantern of extreme lightness, maintained by buttresses, that alone remain solid up to the upper gutters. It is then the construction of these buttresses, that must first occupy us. Here (103) is one of the buttresses of the apse shown parallel to one of the sides. The solid substructure 10.8 ft. high stops at A. At B' is traced the horizontal section at the level B, and at C' is the horizontal section at the level C. D is the glazed opening outside the gallery G. F is the free opening supporting the ceiling H and serving as a passage at the level of the sills of the great upper windows; E is the tracery of these upper windows. The archivolts of the windows tory away at I served as side arches for the great vaults. The upper gutter K is supported internally by the filling placed over the archivolts I, externally by the arch L and the entire system of tracery, whose details we shall give immediately. The tracery D and F is partly set in rebates, so that this tracery is independent of the construction, being actual stone sashes set in the buttresses.

Let us say a word of the materials entering into this structure, for their quality is in part the cause of the system adopted. Even at Troyes, one cannot procure cut stone, the vicinity only supplies chalk, at most good for the compartments of vaults. The architect of S. Urbain of Troyes must have brought stone from Tonnerre for the cut stone parts, and to economize this material transported at great expense, he has employed so far as he could a certain stone called Burgundian, found several leagues from Troyes, which is only a very firm and coarse limestone, but in thin layers and cutting badly. With the latter material he built the massive portions of the buttresses, facing their exteriors M with great slabs of stone from Tonnerre set on edge and finely cut. Likewise with stone from Tonnerre he made these internal piers, the tracery, arches, gutters, and all the delicate parts of the construction; now the quality of the stone from Tonnerre employed here is a thin and very strong bed, very firm and compact, able to



be set on edge without danger. Indeed this construction is a structure in roughed rubble, solid but coarse, faced with a very fine and beautiful stone, used with the strictest economy, as one would do with marble today. The lightness of the tracery, and mullions surpasses all that we know of that kind, and yet the materials employed are so well chosen, the elasticity of this structure is so complete, that very few pieces are broken. Besides the structure being perfectly stable and well weighed, the deteriorations occurring in the tracery and windows are of no importance, these being easily replaced, like actual sashes, without touching the main work. The anatomy of this structure must be examined with the greatest care. We shall attempt to point out the details.

Let us then first take the entire part of the buttress comprised between H and O, i.e., the ceiling of the gallery and its lintel connecting the internal pier to the buttress, the setting of the tracery and the discharging of water at that point. At A (104) is seen the section taken through the axes of the buttress and the pier. B is the gargoyle throwing outside the water collected in the passage G, i.e., not only the rain falling vertically on the slabs, which is little, but also that driven against the glass; C is the through channel, i.e., extended through the entire thickness of the buttress; D is the corbel relieving the lintel E, which serves as a channel that connects the internal pier H to the buttress; F is the cover of the gallery carrying the gutter; I are the two sides forming the external surfaces and maintaining the lintel channel E, as indicated at I' in the perspective sketch K. In this detail the block E' is the lintel channel; C is the second channel, and B' is the gargoyle. The larger detail L shows in place the two blocks I at I'', the channel C at C'', the covering block F at F'' with the lintel E at E''. All this masonry is made with the greatest care, the stones are well cut and set; so that no rupture is seen. Note that the channel-lintel E (detail A) is left free in its span from R to S under the blocks I; i.e., the bed R S is thick and is grouted only after the settlements of the structure have produced their effect, so as to avoid all chance of rupture. One sees at M (detail L) the grooves designed to receive the external glazed tracery of the gallery, and at N those intended to receive



the internal tracery supporting the covering piece of the tracery of the windows. How could such thin tracery both be maintained in vertical planes? The internal has a thickness of only 8.2 ins. and the external one of 8.7 ins, including all projections. Their rigidity is obtained by the simplest means, since the arch of each between the grooves just mentioned is in one piece. Each tracery is thus merely composed of three pieces; two mullions of a flat slab pierced by openings. There should not be forgotten what we have said above of the materials employed in the construction of S. Urbain. The architect made his structure resistant with common stone, a sort of dressed rubble, and everything accessory, decorations, gutters, tracery, of stone from Tonnerre, of a low bed, very firm but of great dimensions in lengths and widths. These stones from Tonnerre are really only slabs with thicknesses varying from 7.9 to 11.8 ins., of excellent quality. The edifice is only composed of buttresses between which are set the flat perforated slabs. This singular system of construction is everywhere applied with that rigorous logic, which characterizes the architecture of the end of the 13<sup>th</sup> century.<sup>1</sup>

Note 1.p.128. How is it that we, who possess cast iron today, or even that we could procure cut stone of excellent quality and in great pieces, have not thought of putting in practice the method so happily applied to the construction of church S. Urbain? What resources would not have been found in the study and use of such a true, simple system, that is so well suited to many of our edifices in which are required great openings, lightness, and that we must erect very rapidly?

Let us then take the external tracery of the gallery of the choir of S. Urbain, to examine how it is cut and set, and how it is maintained in its vertical plane. We draw it here (105) in plan at A, in external elevation at B, and in section at C. The covering stone D, making these two tracteries stable, forming a gutter and the sill of the upper window, is made of one or two pieces of stone joining under the piers and drawn at F" in detail L of Fig. 104. To give more weight and rigidity to the great perforated slab forming the glazed external tracery (Fig. 105), whose section is traced at E, that slab supports a balustrade G continuing it and made of the same piece, so that the gutter D forming the ceiling of the gallery



is borne on a projection reserved inside and along the external tracery, while the lower bed of that ceiling intersects the internal tracery, likewise composed of a flat perforated slab maintained at its ends by the grooves N of our detail L of Fig. 105. It must be said, that to produce a more striking effect the architect has given to the open internal perforated tracery a more delicate design, and a form different from the external tracery, these two traceries thus produce the most brilliant perforations with a surprising play, when detached from the ground of colored glass.<sup>1</sup>

Note 1.p.189. This decoration that encloses the sanctuary of S. Urbain was not probably admired by all at Troyes; for a several years since, they had the idea of hiding it by an enormous decoration made of plin and pasteboard painted white. Nothing is more ridiculous than that scaffolding of pasteboard, which exposes its pretentious misery before one of the most charming conceptions of the art of the 13 th century in its decline. Barbarism that devastates is certainly more dangerous than the barbarism of the authors of the high altar of S. Urbain; but still, what would be said by the friends of art in Europe, if they saw erected a facade of carved plaster before the western facade of the court of the Louvre, under the pretext of beautifying it? How much progress have we to make yet, to no longer merit the name of barbarous, that we so freely give to times in which certainly one would never be allowed to hide a work executed with intelligence, care and talent, behind useless superfluity, coarse in material and work, without form or taste, produced by ignorance combined with the most ridiculous vanity.

Let us now see the upper part of the construction of the choir of S. Urbain, for there our architect has displayed a remarkable sagacity. If we return to Fig. 103, we shall observe that the upper windows are set vertically under the eave wall of the roof at I, that their archivolts serve at the same time as side arches and as discharging arches to support the carpentry, that the gutter K rests partly on a projection reserved above that archivolt and on tracery L placed about 1.6 ft. before the window. Here (106) at A is the external face of that tracery; at B is the section made on C D E F. On that section is found at G the section of the window, its archivolt=



side arch at H and the vault at I. The tracery supporting the gutter K is composed of an arch reinforced by a gable fulfilling the functions of carpentry ties. Perforated circles L c contribute to support the gutter in its span from E to M. This gutter in each bay is only made of two pieces of stone joining at the top of the slopes at N; each of these pieces is cut as indicated at O, the span on the tracery being from E' to M', and the part P being cut away and without drip to allow the apex of the gable to pass. The jointing of this gable and of the open circles L is truly shown in our Fig. The cross-flower, its base intersecting the balustrade of the apex of the gable are made of a single piece of stone, so as to add a weight necessary at the end of the jointing. But to avoid all chance of the overthrow of this gable outward, the two pieces of the balustrade R are not set in a straight line, but form a slightly obtuse angle, as indicated by the plan S; T being the base of the cross-flower and the apex of the gable, and R'R' being the two pieces of the balustrade, each cut in a single slab; thus the apex T of the gable cannot be pushed outward, abutted as it is by the two perforated slabs R'R' resting against the tops of the buttresses pierced by gargoyles for discharging the water, as seen at V. This is rather a combination in carpentry than a masonry construction; but let us not forget that the quality of stone employed at S. Urbain lends itself to such a structure, and that thanks to these artifices, the architect came to erect a monument of extraordinary lightness, actually composed only of rubble masonry and of perforated slabs set on edge. The flying buttresses that abut the great vaults of that church above the chapels are constructed according to this system of tracery and of large blocks of stone set like shores (Art. Arc.-Boutant, Fig. 66).

The architect of S. Urbain (his data being accepted) was faithful to his principle in all parts of his structure. He understood that in such a light edifice, built of rubble and slabs, he must leave to these traceries great freedom to avoid ruptures; so he has only set these slabs in grooves, that allowed the masonry to settle without breaking the delicate perforated enclosures that replaced the walls. In examining Fig. 106, it is seen that the gutters are free, almost reduced to the role of spouts, and that even assuming a break, the leaks



cause no injury to the masonry, since these gutters are hung over the external void by means of those perforate gables. It would be necessary to be bold to conceive a structure of this kind; it would be necessary to be skilful and careful in execution, to calculate everything and to leave nothing to chance; thus this construction, in spite of its excessive lightness, of neglect and of unintelligent repairs, is still stable after 560 years of existence. The architect has required from the quarries of Tonnerre only slabs, or at most beds 11.8 ins. thick, of large dimensions it is true, but of quite small weight; thus he avoided the greatest expense at that time, that of transportation. As for the workmanship, that is considerable; but that did not then cost most. The church S. Urbain will frequently appear in the course of this work, for it is certainly the extreme limit that stone construction can attain, and as an architectural composition it is a masterpiece. (Arts. Arc-Boutant, Balustrade, Croix, Fenetre, Gargouille, Porche, Porte, Vitraux).

It is necessary for us to return somewhat on our steps. In Ile-de-France, as we have already stated, we cannot show the boldness of the Burgundians of the beginning of the 13<sup>th</sup> century, and of the people of Champagne of the end of that century, when they could employ large materials, hard, close-grained and resistant like the stone from Tonnerre. The constructors of Ile-de-France rarely made tracery from a single slab or perforated inclosures; then maintained the stability of their edifices, less by areas or by rigid struts, than by loads accumulated at points appearing to them to not have sufficient bearing. We find a remarkable proof of this fact, after the middle of the 13<sup>th</sup> century, in the great structures.

We have seen that the Gothic architects had come in vaulted edifices to regard the side arches as discharging arches, and to leave entirely void the construction beneath these side arches, retaining only buttresses. They suppressed walls as being entirely useless accumulations of materials between the buttresses, since these must receive and support all the loads; but these side arches not being loaded at the crowns, could deviate from the vertical plane, because of the pressure and the thrust of the courses of rubble of the vaults that they received. Let us state (107) that the side arch A B C, at the

and no injury to the country, since these people are not  
 but are actually void of any of these qualities.  
 would be necessary to be told to possess a knowledge of  
 the kind, it would be necessary to be skillful and careful in  
 question, to calculate everything and to leave nothing to  
 chance; this is the consequence, in spite of the excessive  
 stress, of neglect and of unskillful results, is still  
 liable after 25 years of existence. The situation has remai-  
 ned the same of Tonnerre only alone, or at most both  
 the two, of large dimensions it is true, but of course  
 will without thus avoiding the greatest expense at least  
 and, that of transportation. As for the workman, that is  
 unalterable; but that is not done now. The second  
 point will be to study in the nature of the work, the  
 and especially the extreme limit of the construction  
 again, and as an architectural composition it is a master-  
 piece. (After the French, English, Dutch, German, Italian,  
 Europe, Rome, Venice).  
 It is necessary for us to retain somewhat on our side. In  
 the de-France, as we have already said, we cannot know the  
 address of the Burmese at the beginning of the 18th cen-  
 tury, and of the people of Cambodia of the end of that cen-  
 tury, they would rather have been in the same situation.  
 and resistant like the stone from Tonnerre. The construc-  
 tion of the de-France rarely made traces from a single slab  
 of unworked limestone; then maintained the stability of a  
 wall, less by areas or by right angles, than by 10-  
 articulated at points appearing to them to not have suffi-  
 cient height. We find a remarkable proof of this fact, the  
 the middle of the 18th century, in the great structures.  
 We have seen that the French architects were in vain  
 efforts to obtain the same effect as the Chinese, and  
 have actually with the construction of a stone wall  
 only, retaining only the surface. The Chinese, while  
 and finally a very successful of materials, even the  
 structure, since these are massive and support all the loads  
 of stone also cannot be built in the same way, and  
 from the vertical axis, because the structure  
 in the center of the column at right of the vertical axis  
 received. Let us state (107) the side from A to B, at the

apex B of the two branches of the arch, where this pointed arch is most flexible, receives just the last courses B D of the filling, that have a slight effect of thrust from D to B because of their curvature. The apex B might deviate from the vertical plane, if it were not rendered immovable. To erect a wall on this side arch A B C could consolidate that arch but slightly, since these two triangles of masonry A E B, C F D would load the haunches of this arch much more than its crown B. The most certain means would be to load this crown B. Then about the middle of the 13 th century the constructors came to erect on the exterior and on the side arches of the vaults also enclosing openings, gables H I G of masonry, thus by the addition of this load B G rendering the apexes of the side arches immovable, or at least sufficiently stable to resist the thrust on the crowns by the fillings B D of the vaults. One of the first experiments with this system is seen at the S. chapel of the Palace at Paris. Note that the architects of Champagne, who had adopted side arches with very great resistance because of their great width, since they were actual pointed tunnel vaults, receiving the fillings of the vaults; that the Burgundian architects, who isolated their side arches from the external walls by leaving between them and these walls a space wide enough to be stayed by the crowning courses, had no need to resort to the artifice explained by Fig. 107. Hence it is only rare in Ile-de-France, Beauvoisis and Picardy, that we see about 1240 adopted this means of giving stability to the side arches. Thus differences in the character of the architecture of the different provinces of France in the 13 th century are almost always explained by a necessity of construction. If one desires to take into account the utility of these gables, generally regarded as an ornamental motive it is necessary to examine Fig. 108.

But architecture is an imperious art; when you modify one of its members, when you add something to the arrangement, you see differences in detail accumulate. A first change in the system, that you at first assume to be of little importance, requires a second, then a third, then a multitude of others. Then it is necessary to recede, or to become the slave of requirements aroused by a first experiment or a concession. One contests these successive difficulties, that seem to grow as

or B of the two branches of the arch, where this pointed  
 and in some flexible, receives that the last courses B D of  
 a filling, that have a slight effect of raising from D to B  
 towards the central curvature. The arch B might deviate from the  
 vertical plane, if it were not counteracted by the weight  
 of the filling above it. It would be a mistake to suppose that  
 the arch B is a simple curve, since there are other forces at work  
 and that the thickness of this arch when more than the crown  
 The most certain means would be to load this crown B. The  
 and the weight of the B in the arch the arch is not  
 support on the exterior wall on the side of the arch  
 so as to be a simple curve, since there are other forces at work  
 direction of this load B is rendered the courses of the side a  
 these irregular, or at least sufficiently stable to resist  
 a thrust on the crown of the filling B D of the vault.  
 of the first experiments with this system is seen at the  
 example of the Palace at Paris. Note that the arches  
 themselves, and are loaded with stones and are not  
 being because of their great weight, which they are not  
 load the vault, receiving the filling of the vault  
 as the horizontal arches, and loaded with stones  
 from the external walls by leaving between them and these  
 the arches with stones to be raised by the crowning courses  
 , and as need to resort to the arches explained by Fig.  
 . Hence it is only rare in the arches, Beavers and  
 arches, that we see about 1840 adopted this means of giving  
 stability to the arches. This difference is the result  
 of the construction of the different arches of France  
 from 18th century are almost always explained by a necessity  
 of construction. If one desires to take into account the  
 effect of these causes, usually related to the construction  
 , it is necessary to examine Fig. 108.  
 The construction is an important art; when you modify one of  
 the details, when you add something to the arrangement, you  
 differences in detail accumulate. A first change in the  
 system, that you at first assume to be of little importance,  
 creates a second, then a third, then a fourth, and so on.  
 also it is necessary to consider, to be before the eyes of the  
 architects caused by a first experiment or a concession. One  
 constant these successive alterations, which are in fact

he conquers them. In a time when idleness of mind is regarded as a virtue, men treat these perilous experiments as perverse tendencies, forgetfulness of sane doctrines. But the architects of the middle ages, and particularly of the epoch occupying us at this moment, never believed that a step backward or a repentance was an advance; they felt themselves carried onward by their own principles, and they solved courageously each of the new difficulties, that they raised without rest.

To place over the side arches triangles of stone to load their crowns, at first sight is only a little more stone and a little more work. But gutters are needed over the side arches and balustrades on these gutters; it is necessary for these gutters to rest on the side arches and not on the fillings of the vaults; also that the slopes of these gables themselves reject the water somewhat; these rigid lines must be ornamented, it is this new member added to the architecture that finds its place without encroaching on that of the other indispensable members. Our Fig. 108 explains how the constructors of the middle of the 13th century knew how to harmonize both purely material requirements and those of art. Their side arch A (See section) turned and frequently doubled by the archivolt B, with the depth of the rubble filling of the vault, they set on about two thirds of the width of these arches the solid gable C, arranging an offset of little depth at its base to receive the gutter D set on the last third of the width of these arches. The gable being removed, this gutter bore the moulding crowning the cornice, as seen at E, and received the balustrade in a groove, according to custom. Two stones F with basins and gargoyles were arranged at the base of the gable to collect the water falling on the copings covering these gables. These copings were cut in long pieces of stone to avoid joints according to the sketch G, and below the cornice were inserted in the tympanums behind the crockets set in grooves, with a little drip I to receive the water and conduct it into the basins of the gargoyles. Above the cornice, these copings were cut as in the sketch H, casting the water before and behind. A finial K in a single piece of stone kept in place the ends of the two inclined copings as well as the branches of the crockets. The balustrade J, being set behind flush with the rear of the gable, so as to allow the passage of the



rows of crockets  $M$  inserted in the grooves. Later these gables appeared too heavy and were recessed above the very light tracery of the windows. This example illustrates how each new member added to Gothic architecture brings a series of details, studies and combinations. Perhaps some one will say to us, that these are very great efforts for the motives that cause them; the criticism would be just, but it strikes much higher. In the natural order, how many completed combinations do you not see, details, long and great efforts to produce apparently small results. We have not created the world nor controlled its arrangement; and if things are well arranged, it must be recognized that this arrangement is nothing less than simple. The architects of the middle ages will allow a criticism, that might be addressed to the great ordainer of the universe. Like their predecessors, those architects had inert matter at their command; they must have submitted themselves to the laws of gravitation and of resistance, taking account of wind and rain. In presence of inert matter and the action of natural forces, they believed that equilibrium was the true law of construction; perhaps they were deceived; but one will at least confess, that they deceived themselves like men of genius, and there is always something good to take from men of genius, even when they are mistaken. Besides, it is necessary to fully recognize, that the more man seeks, combines and complicates matters, the sooner he comes to verify the weakness of his judgment. See the rationalists (pardon me the word), artists that follow a principle true for all, conforming themselves to the most rigorous rules of logic, who take cut stone for building, i.e., a material formed to be used superposed in courses; in brief, the principal lines of their structures must be horizontal. No, after a half century of research, the combinations each more ingenious than the others, on the contrary they came in their edifices to cause the vertical line to dominate over the horizontal line, and that without ceasing for a single instant to follow the consequences of the true principle, that they have placed. Many causes then lead them to that result. We have mentioned some of them, as for example, the utility of stones set on end to stiffen structures, the need of loading points of support drawn to leave the vertical by oblique thrusts. It is the last of these which has its

as of objects & limited in the process. These same bodies  
constituted the body and were contained above the very limit im-  
posed by the window. This essential distinction was made in  
order that in certain circumstances there be a series of details  
which are characteristic. Because some are will never be, and  
are the very same efforts for the entire that come about  
in a particular world in fact, but in a different way. It  
is a material object, and many complicated possibilities as you see  
it. Because, food and great efforts in certain circumstances  
all results. We have not created the world nor controlled  
a circumstance; and if things are well arranged, it must be  
arranged that some arrangement in nature have been made.  
In a particular, the right side will allow a particular, that  
will be referred to the great order of the universe. It  
is a particular, those arrangements and in fact rather as  
it is possible, they have been arranged themselves to do it.  
of investigation and of resistance, taking account of wind  
to rain. The process of that order and the order of the  
process, they believe that something can be done for the  
unintentional; because they are localized; but can will be im-  
possible, that they believe something like that of nature,  
it is always something as that can be done,  
and they are mistaken, because, it is necessary to be  
responsible, that the order can be made, because the order  
is matter, the matter is done to make the order of the  
universe. See the particular (because in the world) of the  
the follow a particular rule for all, and that is the same  
the most efficient rule of nature, and that is the same for  
all things, that a material formed to be used according to  
nature, in fact, the natural laws of that universe  
are the natural. We, after a half century of research, have  
found that each more interesting than the others, on the con-  
trary, they are in their efforts to make the natural laws  
be followed over the horizontal line, and that without regard  
to a single instance in which the connection of the line  
is not, that they have found. We believe that the  
the same. We have mentioned some of them, as for exam-  
ple, the study of stones set on end to suffer structures.  
the need of leading points of support given to leave the vert-  
ical to achieve balance. It is the fact of nature which makes

importance. In cities of the middle ages land was scarce. Every city was fortified because of the feudal system, and it could not move the fortifications every ten years. Therefore it was necessary to place the monuments in narrow spaces, to occupy only the least possible area. Now if you build on a principle that makes all the forces of your structure oblique, and if you cannot extend it, it is very necessary to use vertical loads instead of the area lacking. A law at first imposed by necessity, and to which one submits as such soon becomes a habit and a necessity, so much so, that even when one can free himself from it, he submits to it, it pleases him and has become a custom. When architects of the middle ages understood, that the condition of their vaulted edifices led them to multiply the vertical loads to resist all oblique pressures, they have frankly taken their role, and since it is so necessary in an edifice for the horizontal line to dominate the vertical line, unless they resolve to make an actual network, they came to almost entirely suppress the horizontal line, no longer retaining it except for leveling stones, to indicate an internal resting place or floor. Besides, always and more consistent with their principles, the masters of works at the end of the 13th century clearly indicated on the exteriors of their edifices the internal arrangement, and in that we should do well to imitate them. Let us examine a Gothic building externally, and we shall say whether it is vaulted or in stone or covered by carpentry.<sup>1</sup> Its pinnacles will indicate to us the number of internal points of support; its bands, the tops of its vaults; the strength of its buttresses, the energy of the thrusts and their direction; its windows, the number of the side arches of the bays; the form of the roofs, the perimeter of the different halls, etc.

Note 1.p.197. In this respect, and to demonstrate to what extent opinions on architecture are false today, we shall cite the judgment of a very intelligent man, who seeing external buttresses indicated in a project, claimed to have them omitted by the architect, giving as a reason, that the progress of construction must cause the omission of these appendages applied to edifices in barbaric times, and that indicated nothing but ignorance, etc. As much as to say, that we are too civilized to be true, and that a deception is the surest mark of

[illegible]

progress.

Already at S. Urbain of Troyes, the different members of the construction are so delocate, they each possess a function so clear and independent, that the architect assembles them, but does not tie them together, he places them beside each other, holds them together by mortises and overlays like joinery; but he avoids tying them together, for this produces homogeneity of all parts, and the constructor fears that in the use of a system in which every part of the structure acts, and resists, possesses its own force or its own resistance, force and resistance that can only be efficient, when they are independent. At the beginning of the 14th century, this system of leaving to each member of French constructions its proper function, and of connecting these members because of the particular function of each one, is pushed even to exaggeration of the principle. That is very apparent in a very interesting monument erected from 1320 to 1330; we desire to speak of the choir of church S. Nazaire of Carcassonne, one of the rare original conceptions of that epoch during which the art of architecture already fell into the application of formulas, and left aside all new attempts and individual expression.

Careful examination and the analysis of this monument have revealed to us a fact interesting to us today; this is the simple method pursued by the architect and his subordinates in erecting a structure very complicated in appearance, and that seems to require a fabulous quantity of operations and drawings. In reality the difficulties in the masonry do not exist. This structure is only an assemblage of vertical planes whose revolved positions only require a single drawing. It must indeed be admitted before all else, that the architect knows what he wants, that he sees his edifice in all its aspects before commencing the foundations, that he has taken into account the different parts of his structure; that he has done the work before the cutting of a stone, that we do in an edifice when we measure and examine it in its least details. Gothic architecture is over particular on that point, and perhaps this is why it has made so many enemies. It is consoling to say, when a difficulty occurs in the work; "We will see to that in the finishing." It is so painful, when all is not foreseen in advance, to hear daily a long series of questions presented by



the stonecutter or the foreman; questions that must be answered clearly and simply, like a man that knows what he is going to say, as if he had foreseen what would be asked him! Then the architect of the choir of S. Nazaire of Carcassonne not only made the plan of his edifice, not only the elevations and sections, but he knew in advance the exact points of the imposts of the different arches, their meeting and intersection; he knew the results of the thrusts, their direction and force; he had calculated the loads and reduced the forces and resistances to their most proper limits. He knew all in advance that it was necessary for him to know, from the first course laid above ground. His conception being thus complete, fixed on paper, and in his head, his subordinates proceeded blindly. He said to one, "Here is the drawing of the pier A, which is repeated twice; here is the drawing of the window A, that is repeated six times; here is the drawing of the buttress C, that is repeated ten times, etc., that of the window B to be repeated seven times; here is one branch of the pointed arch with its imposts, of the transverse arch with its imposts, etc." That being said, the architect can go away and allow the cutting of all the pieces of each member. The cutting finished, a master setter then comes, who without possible error, hoists and assembles all these different pieces, necessarily all taking their places like the parts of a well conceived machine. That method of procedure explains how at that epoch (at the end of the 13<sup>th</sup> century and in the 14<sup>th</sup>), French architects caused the erection of monuments in countries in which perhaps they had never set foot, how men demanded in Spain, southern France, Hungary, Bohemia, projects of monuments from those architects, and how those monuments could be erected and recall accurately, except some details of mouldings and sculpture, the edifices built between the Somme and the Loire. The choir of church S. Nazaire of Carcassonne was probably erected thus, by the aid of drawings furnished by an architect of the North, who perhaps scarcely sojourned in the city; what makes us believe this is, that evidently the architect avoided all difficulty requiring a decision at the place, those difficulties not solved by a drawing, but by explanations given to the stonecutters and to the workmen themselves on the yard, following their work by the eyes, taking



up at need the gauge, rule, square, laying them on the drawing. For example, the architect in the vaults of that edifice has almost entirely rejected imposts common to several arches; he has given the curve of section of each; they have been cut without considering the adjoining arch, and the master setter has come to arrange all that like a game of patience. But to make appreciated the singular method of construction employed in the choir of church S. Nazaire of Carcassonne, it is useful to give half the plan of that choir with its transept. (109). We see in that plan the horizontal projection of the vaults; they all have their crowns at the same level or nearly so, although their dimensions and forms may be unlike; necessarily the imposts of these vaults will then find themselves at very different levels. It is necessary to see the general section of this construction on A B. The architect thought of closing the vaults C (110) at a level below the great vaults of the sanctuary and transept; the construction had even been erected thus as far as above the springings of these low vaults, as shown by the dotted lines D E; but the architect had to yield to the desire to produce more effect by raising the crowns of all the vaults to the same level. Perhaps the requirement of the clergy caused the adoption of this last mode; what is certain is that the low springings indicated by dotted lines were cut on the faces of the piers, and easily recognized, and that these springings were raised as our drawing indicates, so as to have on the entire exterior of the edifice windows of equal height. Fig. 111 presents the section on line G H of the plan. let us state at once, that to prevent the bending of such thin piers pushed by unequal thrusts, produced by raising the secondary vaults, the architect has placed ties I of iron 2 ins. square, visible in both our sections; that the stone employed is a hard and very resistant sandstone, that permits placing the vaults on slender points of support. Let us now examine with care the details of that construction, take the head of the pier K (of the plan) at the point where that pier receives a great intermediate arch of the sanctuary, two archivolts, a transverse arch of the chapel and two branches of the diagonal arches. The horizontal section of that pier (112) is traced at A. From B to C we see four courses of impost blocks that receive that great transv-



transverse arch. From the joint C normal to the curve of the transverse arch E, the voussoirs of that arch are independent; the pier rises behind the filling F if that arch without ties to it, as far as to the side arch G. The projection of that capital forms a bond with the filling, and then the pier is independent up to its meeting with the side arch H. Above the capital G the filling rises vertically from I to K. It is perforated by the trefoil L, which decorates this bare triangle and receives the filling of cut rubble. The two iron bars M serve as ties between this pier and the next; they resist the thrust of the transverse arch E.

Let us take the next pier L of the plan, that of the reentrant angle, which finds itself between three mullions, and receives a great transverse arch, two great branches of diagonal arches of the principal vaults, and a third branch of the diagonal arch of the chapel (113). One here sees that the trace of each of these three parts is made independent of the others, and that the masonry only presents the fewest connections possible, to avoid too complicated drawings. This independence of the different members of the vaults springing from the piers leaves great elasticity to the construction, an elasticity necessary in so light a monument, very high and unequally loaded. One indeed can find in the choir of church S. Nazaire torsions and considerable movements, without the building losing anything of its stability. Again, these are not examples to follow, but very useful to know, because of the simple and practical means employed. Let us see the external side of the same pier. (114).

We are placed in the angle of the chapel at the point V of the plan; we assume the upper part of the tracery of the great window of that chapel to be removed.<sup>1</sup> One sees at A the bar of iron that maintains the heads of the little columns of that tracery, and that at the same time serves as a tie at the springing of the arches (Art. Meneaux); at B is the groove reserved for setting the curved open part of the tracery; at C' are the imposts of the side arch that receives the perforated stone tracery; at E is the branch of the diagonal arch of the vault of the chapel, whose two impost courses are combined with those of the side arch. Above the joint D, the voussoirs of this diagonal arch are independent. At G is the arch-



archivolt enclosing the round and perforated arch of the first window of the sanctuary and taking the place of the side arch of the vault in the interior; at F is the archivolt-side-arch of the tracery not glazed and separating the chapel from the choir. Here one will note the reentrant angle behind the diagonal arch E; this proves in the most evident manner that each member of the construction was drawn and cut separately on the yard after partial sketches, and that these different parts thus prepared by the stonecutter were placed by the stone setter, who alone knew each of their functions and their relation in the entirety of the structure. The mason came to fill the intervals remaining between these members confused together and intersecting, while remaining entirely free. We have traced at K the horizontal projection of this reentrant angle with the intersection of the two archivolt-side-arches G.

Note 1.p.204. This operation having been done under our eyes, we have been able to recognize very accurately and reproduce here this construction.

Such a construction is only composed of piers receiving elastic and resistant ribs, supporting the fillings of the vaults, or maintaining the stone sashes in the wide grooves; it makes us know that the master of the work could abandon nothing to chance, could postpone nothing, foresee all from the first course, arrange his drawings systematically, and that after the stone was cut according to these drawings and the blocks were ready, he only needed to give instructions to a skilful setter, who successively took all parts of the edifice and placed them in their order, as the carpenter's laborer takes one by one the timbers of the carpentry framed in advance to the site to place them for raising. Today we proceed otherwise; blocks of stone are collected often without knowing the definite form that they will assume, and on these blocks are cut the intersections of the imposts and the mouldings, as one would do in a homogeneous mass, without caring much for the beds and joints, that do not coincide with the forms given. Is this better? Is this the means of obtaining more stable structures? It is permitted to doubt it. Yet one can state that it is less reasonable, less skilful, less intelligent and more costly.

There is no religious structure of the middle ages more ad-



advanced than that of church S. Urbain of Troyes and S. Nazaire of Carcassonne in the path opened by the architects of the 13th century. Indeed one could not go beyond it without substituting metal for stone. Either the architects of the 14th century were arrested by the impossibility, or unlucky attempts proved to them, that they had already passed the limits imposed by the material, there was always a reaction about 1330, and the constructors abandoned these too bold methods to return to a wiser system; but this reaction had as an effect the destruction of originality; men came to formulas. At that epoch we see the architects leave aside in the live works of their structures, the simultaneous assemblage of stones on their beds and their edges, which furnished the constructors of the 13th century such beautiful motives of architecture; they retained the forms imposed by this system, but no longer appreciated the reasons for them; losing something of the adventurous spirit of their predecessors, they renounced stones on edge for points of support and means of rigidity, and returned to structures built in courses, reserving stones set on edge for tracery, facing arcades, i.e., for architectural members in carrying a load, and merely sashes on decorations. Yet as if to follow, at least in appearance, the consequences of the system of construction adopted in the 13th century, they multiplied vertical lines, they desired that in only the members of the vaults, the arches, should each have their point of support, but even the mouldings by which these arches are decorated. Therefore it results between the form given to the piers, for example, of the construction of these piers, there is the most evident contradiction. In fact the constructors of the 14th century returned to heavier forms, although they strove to disguise this reaction under an appearance of lightness by multiplying the small architectural members. As practitioners, they are very skilful, very prudent, full of experience and adroit; but they entirely lack invention; they have no longer the boldnesses denoting genius; they are wiser than their predecessors of the 12th century, but they have the defects which frequently accompany sagacity, their safe methods and formulas are impressed by a fatiguing monotony, in spite of all their efforts.

The most striking and one of the most complete example of

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the religious construction of the 14 th century is the cathedral of Narbonne, whose choir only was built from 1370 to 1400.<sup>1</sup> This is the work of a consummate master in his art, but without that imagination and those unexpected resources, which charm in the structures of the 13 th century, and that lend themselves to the most varied conceptions. What gives the degree of practical skill to which the architects of the 14 th century had attained was the renewal of the lower work, those partial reconstructions made in the oldest edifices. At that epoch the materials employed are always of the first quality, the drawing is wise and the construction excellent, the cutting executed with remarkable care. Besides the general system of construction is modified very little, it is applied with more certainty and with a perfect knowledge of passive and active forces, of loads and thrusts. For example, the flying buttresses are well drawn and are set exactly as they should be. We have a very evident proof of this at the cathedral of Paris. All the flying buttresses of the nave were rebuilt at that epoch (about 1330), and rebuilt in such a manner as to be above the galleries of the second story, and to spring from the great external buttresses. (Arts. Arc-Boutant, Fig. 59; Cathédrale). These flying buttresses, which have a very long radius and consequently a very flat curvature, were calculated with an exact knowledge of the function that they had to fulfil, and when one thinks that they must have been rebuilt in novel conditions, supporting old constructions, one is compelled to recognize in these constructors of the 14 th century a great experience and uncommon skill. We do not believe that it will be necessary for us to enlarge further on the religious structures of the middle ages, for we shall teach nothing new to our readers after what we have already stated. The Articles of the Dictionary will further exhibit the differences resulting from the perfecting of details introduced by the architects of the 14 th and 15 th centuries in religious structures. We shall now occupy ourselves with civil and military buildings, that proceed after their particular methods, having but little relation to structures purely religious.

Note 1.p.201. It is necessary to state, that we do not have in France a single great and complete edifice of the religious architecture of the 14 th century. The 13 th century left

the scientific construction of the 14th century is the same -  
 val of German, whose choir only was built from 1370 to 1380.  
 in is the work of an anonymous master in his art, but with-  
 a great feeling and almost unconscious treatment, which has  
 the same character of art as the master, and that is the same  
 lives as the most varied and beautiful. The 14th century  
 a practical skill to which the architect of the 14th century  
 has attained was the renewal of the lower work, those par-  
 tial reconstructions made in the oldest edifices. At that es-  
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 building is wise and the construction excellent, the con-  
 struction with reasonable care, besides the general style  
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 in the other parts of the church. The flying buttresses, which were a very fine  
 and beautiful a very fine example, were calculated  
 in an exact manner of the building and in the  
 all, and when one thinks that they must have been rebuilt in  
 the middle, according to the construction, one is amazed  
 at the perfection in their construction of the 14th century.  
 and construction and construction with it. It is not before that  
 will be necessary for us to study further on the scientific  
 on the principles of the middle ages, for we shall reach nothing  
 as to our readers after what we have already stated. The in-  
 tention of the Dictionary will further assist the following  
 results from the perfection of details introduced by the ar-  
 chitects of the 14th century in the various parts  
 of the church. We shall not attempt to give a full and complete  
 account, then, of the details of the construction, having  
 the little relation to architecture nearly finished.  
 1. p. 201. It is necessary to state, that we do not have  
 a single great and complete edition of the middle  
 of the 14th century. The 14th century

in great monuments of that kind to be built. The 14 th century could only complete edifices already commenced, that had no leisure to finish the small number that it founded.

#### CONSTRUCTIONS CIVILES- Civil or secular Structures.

About the first times of the middle ages, Roman traditions were perpetuated on the soil of Gaul in civil structures as well as in military works; yet wood then played a more important part than in the Gallo-Roman period. The Gallo-Roman system of construction does not differ from the Roman system; the same procedures are employed, ruder in regard to execution. During the Merovingian period, one recognizes a very frequent use of wood, not only for coverings but in ceilings, wainscotings, porticos, and even the walls of habitations. Germany and Gaul produced wood for carpentry in profusion, and that material being easy to use, it was natural to use it in preference to stone and brick, that require difficult quarrying, cutting, hard transportation, or a previous burning and time.<sup>1</sup>

Note 1.p.208. It was scarcely until the end of the 13 th century that the forests of Gaul began to lose extent and quantity, i.e., at the moment when the feudal organization decreased. During the 14 th century many feudal lords were obliged to alienate in part their properties, and the monastic establishments, chapters or communes cleared a notable section of the forests of which they had become possessors. At the time of the wars of the 14 th and 15 th centuries, the forests in many localities being no longer subject to conservation and control of the feudal system were cruelly devastated. Those that existed on the mountains were thus forever lost, because of the removal of the earth on the steep slopes. Thus the South and the entire centre of present France were depopled of the forests, that covered the plateaus, and whose existence was still proved about the end of the 13 th century.

The fires that destroyed such a great number of cities and market towns during the 9 th, 10 th and 11 th centuries, contributed to cause the abandonment of wood in construction of private buildings as in the construction of churches. Men no longer used this material, except for floors, roofs and internal partitions of habitations. Already in the 12 th century, a number of cities presented facades of houses in cut stone



or rubble, except in certain areas without quarries, for example as in Champagne and Picardy.

The monastic establishments, so rich in the 12 th century, gave the example of civil structures in stone, and that example was followed by private persons. It must be stated to the honor of the constructors of that epoch, that in adopting cut stone or rubble in place of wood, they very probably took a mode of construction appropriate to those materials, and did not seek in their use to reproduce the forms or arrangements suited to wood in carpentry. Always disposed to preserve to the material placed in the work its real function and the appearance suited to it, they did not attempt to disguise the nature of the material. Further, the means employed were extremely simple, and those artists that exhibited a singular subtlety in their religious structures after the 12 th century, a search for such complicated means, contented themselves in civil buildings with the most natural and least labored methods. Economies in materials that then comparatively cost more than today, during the 12 th and 13 th centuries, their houses are reduced to the essentials, without pretending to seem more or other than they are, i.e., walls pierced by openings, supporting floors composed of beams and visible joists, well sheltered next the street and the court by projecting roofs, that cast the water far from the walls. Very rarely, except in some cities of the South and Centre, the ground story was vaulted; consequently no buttresses or projections on the exterior. Most frequently walls of visible dressed rubble with some bands, jambs and lintels of doorways and windows in cut stone; also these lintels and jambs did not extend through but only faced the exterior; the bands alone connected the two internal and external faces of the walls.

To give an idea of these civil structures most common in the 12 th and beginning of the 13 th centuries, of the simplicity of the means employed, we select from a very great number of examples one of the houses of the city of Cluny, so rich in houses of the middle ages. Here (115) is the face of the external wall of this house on the street. One sees that the construction only consists of rubble masonry with some cut stone for the bands, arches, windows and their lintels. The lower arches open into the shops. At the right of the door

...in certain cases without doubt, for example, in the case of the ... and Prosperity.

The economic establishments, so true in the 12th century, ... the example of civil architecture in stone, and that example ... of private patronage, in the case of the ... of the architecture of that epoch, that is to say, the ... in place of wood, they very probably took a ... to construction appropriate to those materials, and did ... to reproduce the forms or arrangements ... to wood in carpentry. Always disposed to preserve to ... in the case of the ... and ... to it, they did not attempt to disguise the ... of the ... the ... with ... and ... that existed in ... in their ... in the 12th century, ... for ... in ... with the ... and ... in ... in ... the 12th and 13th centuries, their houses ... to the essentials, without pretending to seem ... walls pierced by openings, ... floors composed of beams and visible joists, well ... the street and the court by projecting roofs, ... the water far from the walls. Very rarely, except in ... of the South and Centre, the ground story was ... no buttresses or projections on the exterior, ... of ... and ... in ... and lintels of doorways and windows in our ... and ... not extent through ... the exterior, the bands alone connected the ... and external faces of the walls.

... these civil structures most common in ... of the ... of the ... we select from a very great number of examples one of the houses of the city of ... in ... of the middle ages. Here (115) is the face of ... of the ... and ... only consists of rubble masonry with some ... the ... and ... At the right of the door

to the alley leading to the stairs. The second story presents an open gallery composed of piers and little columns and lighting the great hall. The openings are rectangular and receive casement sashes. In the lintels and under the internal arches supporting the wall of the third story are pierced little transom windows. The third story is lighted by a gallery of less importance, and a strongly projecting roof casts the water far from the surface. In plan the second story gives Fig. 116, and Fig. 117 reproduces the front seen from the interior, with its discharging arches above the lintels of the second story, the benches of the windows, and the span of the beams supporting the joists. These principal beams, set against the face of the wall between the arches connected the two parallel walls of the house and served as ties; they were relieved in span by wooden corbels, as shown by the section (118). (Art. Maison). There is the simplest expression of private architecture during the middle ages; but the civil structures did not always have such a frank character. In the great habitations and castles the services were much more complex, the inhabitants very numerous, and it was necessary to find internal arrangements and lobbies. Yet there were certain general arrangements, which remained the same for the nobleman's habitation as for that of the citizen. It was always essential to have a hall, the place for the gathering of the family of the citizen, of the household of the lord;<sup>1</sup> then the chambers with their wardrobes and closets, lobbies to reach these rooms with private stairs; thus there were under the same roof very large rooms and others very small, passages, air and light everywhere. One frequently assumes quite erroneously, that the habitations of the lords, as well as of the petty citizens of the middle ages, could only be dark and gloomy, badly lighted and poorly ventilated, that as again one of those absolute judgments, that should not be applied to that epoch. Unless arrangements for defense obliged the lords to open only very few windows, on the contrary they sought in their castles light and air, a view of the country, and different orientations so as to have everywhere sunshine or coolness at will. However little men take the trouble to think, they will indeed understand, that men who passed the greater part of their lives in traveling over the country, could not with good



will shut themselves in, sometimes for entire weeks, gloomy chambers without outlook, air and light. If the defensive arrangements of a residence compelled the occupants to open the fewest possible windows on the exterior, if the courts of the castle surrounded by high buildings were frequently gloomy and dark, yet the inhabitants sought by all sorts of ingenious means to obtain for themselves views over the country, air and sunshine. Hence these little flanking turrets, those watch turrets, corbellings, square recesses that permitted opening windows masked from the exterior. Very sensible customs also imposed on the architects particular arrangements in the great habitations. Men did not admit during the middle ages, no more than in antiquity, that a great hall and a little chamber should have the same height between floors, that a corridor should be as high as the rooms that it served. There have been necessary centuries of false reasoning in architecture to forget such true principles, and to compel us to live in great halls with low ceilings, if the story that we occupy is low, or in little cabinets of excessive height, if we have a story 13.4 or 16.4 ft. between floors. For the great cities the stories being necessarily fixed, one again understands that that necessity has imposed arrangements as inconvenient as ridiculous; but where the architect is free in a pleasure house or chateau, it is unreasonable to not take into account the dimensions and areas of the rooms and not fix the height proper for each one, to light cabinets or corridors by windows having the same dimensions as those opened into great rooms, to cause lateral corridors to obstruct all windows on one face of the building, the landings of stairways to cut across windows at half their height, mezzanines taken at the expense of the great windows, to not disturb a certain order of architecture, that is of little importance to the occupants of a palace; or indeed also to establish, in the midst of double buildings corridors serving the rooms at right and left, lighted by borrowed light, badly ventilated, dark, noisy like the corridors of inns, losing precious space and loading the floors in their weakest parts.

The architects of the middle ages did nothing at all of all that, and did not even think it possible; we should not blame them for that. Their buildings for residence were nearly all

[illegible]

single in depth, and so that the rooms cut off transversely should not be passed through, which would have been very inconvenient in many cases, they established along the buildings closed and low galleries, that served each room, also allowing windows to be opened over them. Example. (119).

Note 1.p.211. This household comprised not only the family, but the servants, men and women at wages and the entire personnel of the castle.

If the building had several stories, this arrangement could be retained with all its advantages. (120). One sees at A the second story with its service gallery C, over which open the windows lighting the halls; at B is the upper story. Almost always ceiled, lighted by windows with dormers at the side opposite the gallery, and by dormers alone above that gallery. The corridor of the upper story is supported on arches, that allow between their piers the opening of windows lighting directly the second story. An arrangement of this kind still exists at the palace of justice of Paris, in the western part; it dates from the 13<sup>th</sup> century. One cannot disdain what is reasonable and true in such a construction, that gives to each service its relative importance, which leaves to the principal rooms all the air and light which they need, and that very frankly emphasizes on the exterior the services and the internal arrangement of the building. That is certainly more according to good antique traditions, which is not a series of columns or pilasters stuck against a wall, nobody knows why. This is indeed the religious architecture of the middle ages, that varies from antique forms, but long knew how to retain the spirit in civil architecture. We shall furnish another proof of it.

When habitations are vast and the buildings consist of several stories, which the architects of the middle ages did not condemn, for the simple reason that two stories over each other cost less to build, than if a ground story covered an area equal to the two stories, since it is then necessary to double the foundations and roofs, we say that if the building contained several stories, the architect multiplied the stories so that each apartment might have its own. Yet there was always a principal stairway of honor, that led to the rooms intended for receptions. During the Romanesque period, steps of

...in depth, and so that the tower may be prominently  
 ...not be damaged, which will have been very care-  
 ...in many cases, they are situated near the middle  
 ...and the building, and are very small, and are al-  
 ...to be opened over them. Example. (115).

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cut stone were very rare, they were most frequently made of wood, i.e., by superposing short blocks of squared timbers, logs of wood entering somewhat into the side walls. Then the stairs were composed of two straight flights with landings, and they were enclosed in a rectangular stair hall divided lengthwise by a wall. (Art. Escalier). This method was almost entirely abandoned by the constructors of the 13<sup>th</sup> century, who adopted screw stairs with newel and steps of stone, as occupying less space and more conveniently serving the different stories necessary to be reached. If these screw stairs were of very small diameter, i.e., of 5 ft. inside, they were often sunk into the thickness of a wall forming a slight projection externally rather than internally; on the contrary if they occupied a cylindrical or polygonal hall of quite large diameter inside (8 or 10 ft.), they entirely formed an external projection and did not interfere with the internal arrangements. As for detached buildings, each had its particular roof, and if the buildings were double in depth, there was a roof on each one with intermediate gutter. The architects of the middle ages having believed it necessary to adopt roofs with slopes above 45° degrees, and not knowing curb or mansard roofs, could not comprehend a building of double depth under a single roof, for this roof would have reached an enormous height. Each detached building or pavilion, each stairway having its special roof, either pyramidal or shed, or in two slopes with gables or hips, it was easy at need to place these roofs at different levels, thus obtaining high rooms between the floors when they were large, or low when they were small. This method required much wood, and a very extended area of covering, demanded lead gutters inside; but it had the advantage over that consisting in enclosing all the services of a building beneath the same roof, of furnishing the architects varied resources in heights to be given to rooms, permitting them to open a great number of dormers to light the upper rooms, to leave vacant the tops of the stairways, which thus served as watch turrets above the roofs and procured ventilation for the lower stories. As for appearance, these separate roofs covering grouped separate structures, emphasizing their form and purpose, were very picturesque and gave to great habitations the appearance of a collection of houses more or less high,



more or less extensive by reason of the services that they contained. One will conceive that this differed in all points from our modern structures, and it must be stated that these traditions were retained until about the middle of the 16<sup>th</sup> century. As a principle if not in form, one finds in these arrangements the traces of the great antique habitations, the villas, that indeed were only groups of buildings more or less well arranged, but distinct in their form, height and covering. Very little subject to the laws of symmetry, the architects of the middle ages also placed the different services of the great habitations, after the orientation, according to the needs of the occupants and conforming to the form of the site. There was a point of resemblance to the antique villas, which in their entirety had nothing of symmetry. In the towns, then, nearly all fortified, ground was scarcer as in all enclosed cities. In the castles, whose perimeter it was always sought to restrict as much by motives of economy, as for the power of defending them with a less numerous garrison, space was economized. Thus it was necessary for the architects to seek in the city as in the country, to enclose as many services as possible within an area of relatively small extent. In this respect the civil structures of the middle ages differ from those of the ancients, the latter in their villas rarely built more than one story and occupied great areas. Compelled to keep themselves within limited areas, the constructors of the middle ages saw themselves constrained also to take internal arrangements different from those adopted by the Romans, to superpose services, to find lobbies in the thickness of the walls; consequently to seek entirely novel combinations of structures. Yet do not forget this important point, viz:- that antique traditions were perpetuated in civil structures by the very natural reason that everything connected with daily life is transmitted from generation to generation without possible interruption, that habits in interiors cannot be abruptly modified, and that if it be possible to make a radical revolution in the system of construction of public monuments, like churches, it becomes impossible for the houses and palaces that men inhabit, and in which each one has adopted the habit of living just as his father lived.

The system of construction applied at the end of the 12<sup>th</sup>

to be less extensive by reason of the services that they  
performed. One still remembers that this difference in all points  
of our modern architecture, and it must be stated that these  
differences were retained until about the middle of the 15th  
century. As a principle it not in form, one finds in these  
monuments the traces of the great antique traditions, the  
lines, that indeed were only groups of buildings more or less  
isolated, and distinct in their form, height and covering.  
The little subject to the laws of symmetry, the architects of  
the Middle Ages also placed the different services of the res-  
idence, after the primitive, according to the needs  
of the community and according to the type of the place. The  
in a point of resemblance to the modern villas, which in a  
the symmetry and nothing of symmetry. In the towers, when  
the architecture, there was a sense as in all houses  
lines. In the castles, where between it was always some-  
thing as was in medieval times, as for the tower  
including there was a less numerous service, space was  
sufficient. Thus it was necessary for the architect to seek  
the place as in the country, to make as very narrow as  
possible within an area of relatively small extent. In this  
house and civil architecture of the Middle Ages there was  
one of the greatest. The tower in these villas was the  
the main part and the most important element, connected to  
the exterior with a small porch, and surrounded by the  
this was and themselves contained also to take internal  
consequence different from those adopted by the Romans, to  
become necessary, to find lodges in the thickness of the  
the consequently to seek entirely novel combinations of  
construction. The so-called civil architecture of the 15th and 16th  
centuries was characterized in civil architecture by a  
a very natural reason that everything connected with daily  
life is characterized by a certain simplicity and directness.  
The architecture, that facile in its forms cannot be appro-  
priate, and that it is possible to make a radical re-  
vision in the system of construction of civil monuments. If  
in contrast, it becomes impossible for the houses and pal-  
aces and castles, and in some cases one can observe the  
of which that we have seen.

The system of construction applied at the end of the 15th

century to religious edifices had only a weak influence in civil edifices. The pointed arch with its so extensive consequences, as we have shown, scarcely appeared in the latter edifices. Civil and military construction retains something of Roman art, when already the last traces of that art have been abandoned long since in religious architecture. Dating from the end of the 12 th century, there were then two very distinct modes of building; the religious mode and the civil mode; and that state of things exists until about the middle of the 16 th century. The monasteries even adopted one or the other of these modes; buildings for habitation have no relation as a system of construction to the churches and chapels. Yet one of the principal qualities of construction at the moment when it abandoned Romanesque traditions, boldness, is also found in civil as well as religious architecture, but in civil architecture it is evident that positive ideas, daily needs and transmitted habits, have a more direct influence on the methods adopted by the constructor. Thus for example, constructions in rubble and concrete are long found in civil architecture, after all religious structures were erected in cut stone; stone lintels were everywhere employed in the habitations of the 12 th, 13 th, 14 th and 15 th centuries, when one no longer finds a trace of them in the churches. The buttresses, even when vaulted stories exist, are avoided as much as possible on the exteriors of palaces and houses, while they alone form the entire system of construction of churches. Wood does not cease to be employed by civil architects, while it is no longer reserved exclusively except for roofs of cathedrals and of all religious monuments of some importance. Finally, architects seek to avoid solid parts, to diminish the points of support, come to suppress entirely the walls in erecting their great religious structures; while in civil architecture, they increase the thickness of the walls as the customs of comfort penetrate everywhere, and men hold to having the habitations better enclosed, safer and more sanitary. The study of these two modes of building must then be pursued separately, and if we find inevitable relations between these two systems, this is less in the practical means than in that frank and bold charm, those infinite resources, which belong to the lay architects of the middle ages.

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 monasteries were to avoid vaulted roofs, to obtain the light  
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 of these religious edifices, while in civil architecture  
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 with vaulted systems, and were not so having the same  
 as in the interior, after all, were similar. The civil  
 shows the same of building that we noticed in the 13th  
 and in the 14th century. The difference between the two  
 styles is less in the practical means than in that frank  
 in civil work, those infinite resources, which belong to the  
 architecture of the middle ages.

All persons with some notion of architecture know that the Romans, even when constructing vaulted edifices, resisted the thrusts of vaults rather by internal buttresses than by piers forming external projections. Particularly in erecting civil buildings, they had adopted the system of construction that we term cellular, i.e., they composed these buildings of a series of halls with tunnel vaults on division walls reciprocally abutting each other, and exerting no thrust externally. From this principle, sufficiently explained by Fig. 121, resulted the natural consequences. For example, if one desired all these abutting cells to form only a single hall, it sufficed to have a tunnel vault intersect all these transverse tunnel vaults; thus were obtained a series of cross vaults (122), well abutted by the internal buttresses A, the remains of the division walls B, indicated in purpose in Fig. 121. This arrangement permitted the erection at C of solid walls, or of open walls as light as possible, since nothing loaded them. This was a very simple structure, very durable and easy to erect, that long served as a type for the civil edifices of the Carolingian epoch.

To avoid expense, and if one did not absolutely require vaults, they were contented during the Romanesque period to place the floors on two parallel rows of round arches. By this means one could erect several stories over each other, without fearing to see the side walls overthrown, since they were composed of buttresses giving a series of piers in the interior connected by the arches that stayed them; beneath these arches were made openings as large as required to give air and light to the halls. Figs. 115, 116, 117 and 118, which present to us one of the houses built in the 13th century in the city of Cluny, still retain the remains of this Roman tradition, for the front wall of this house is actually composed only of a series of discharging arches masked behind the external surface. If this combination lent itself to the most ordinary civil structures, it was equally favorable to military conditions, as we shall soon see, it was applied very late again in the construction of the great halls of castles and of bishops' palaces, since the hall of Henry II at Fontainebleau shows us one of the last examples, when before was seen a hall of the 13th century in the enclosure of the castle of

All persons with some notion of architecture know that the  
 system, even when constructed by the most skillful, required the  
 exercise of various rather by individual judgment than by some  
 certain standard proportions. Particularly in erecting civil  
 buildings, they had adopted the system of construction that we  
 call the "columnade," i.e., they purchased long building of a series  
 of halls with central vaults on division walls respectively a  
 constant space apart, and extending to lateral extremities. From  
 this principle, sufficiently illustrated by fig. 151, resulted  
 an internal connection. For example, if one desired all the  
 existing cells to form only a single hall, it sufficed to  
 give a tunnel vault intersect all these transverse tunnels and  
 thus form a single hall of great length (fig. 152) well  
 known by the internal passages A, the remains of the div-  
 ision walls B, indicated in section in fig. 151, and the  
 vaulted ceiling C, indicated in section in fig. 152. This  
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 the basis of the structure having a series of arches in the  
 exterior supported by the arches that served them; beneath  
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 light and heat to the hall. Thus, fig. 153, and fig. 154, which  
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Montargis, and that one yet sees at Angers near the cathedral, the old hall of the synod of the 12 th century, both erected according to the same principle. (Art. Salle).

What is very important to note in the civil structures of the middle ages, is the care with which the constructors foresaw even the least details of the structure. If they had to insert a floor, they left properly spaced holes for the beams in the internal surfaces of the walls, and did not cut them afterwards; they set stone corbels under the spans of these beams, they left horizontal grooves along the division walls to receive the plates into which were framed the joists, or holes regularly spaced for their ends. In the splays of openings, they set the hinges while building, and they arranged projections at the inside of mullions to receive the staples of bolts or bars. Their fireplaces were built at the same time as the walls and had the flues cut inside with the greatest care; the jambs of the fireplaces are bonded to the walls and not merely set against them; the passage of the flues through the floors, the supports of the upper hearths indicate an extreme foresight, arrangements studied before execution. All these things would be for us today excellent instructions, if we were willing to see and to free ourselves from that mania of believing that we cannot take anything good from the past, when that past is on this side of the mountains. In great civil structures, such as halls of assembly, and the markets, the constructors of the middle ages almost always have taken care to make lower the upper window openings, the lower windows allowed the sight of what passed outside, and of admitting air, the upper windows sent the light direct from the sky. These elevated openings are made in the height of the roof and form dormers externally. However extensive the halls were in area and height, the windows are always found proportioned to the human height, and what is more important, to the reasonable dimension that one can give to a wooden sash destined to be opened frequently. As for the sashes of the dormers, they opened like skylights by means of pullies and cords. (Art-Lucarne).<sup>1</sup>

Note 1.p.221. Dormers with stone fronts were placed on buildings of the 13 th century, the skill under Louis XIV it was claimed that this mode of making openings at the base of roofs



roofs was invented by Mansard, to consecrate the memory of this useful invention, there has since been given to these openings the name of mansards (?), as if all the civil buildings, chateaus and houses were not provided with mansards under Francis I, Louis XIII, and much before them. But such is the weakness of the 17 th century, that claimed to have invented everything. Now this is only a pretension. It is with that as with many other things at that epoch. It has been written and repeated many times, that the wheelbarrow, for example, was invented in the 17 th century, when the great works of terracing were undertaken at Versailles. We have numerous copies of wheelbarrows represented on the manuscripts and stained glass of the 13 th century. It is true that the forms of these little vehicles at that time is much more convenient for the laborer, than that adopted after the 13 th century, and which we religiously reproduce in our yards, as if there was a masterpiece. It is the same with the dray, said to have been invented by Pascal.

One is too much induced to believe that during the middle ages, however ingenious were the architects, they did not know how to conceive those broad arrangements of the entirety, those vast structures of the civil kind demanded by our modern needs, taking more importance daily, that is again a prejudice. It must be said, that most of our great churches still standing today, cause us to see very well, that in religious architecture the constructors knew how to undertake and complete very vast monuments; but for the civil buildings of the middle ages, changed during the last centuries, condemned to systematic destruction since the revolution, scorned by our French city governments, who give themselves the weakness of Louis XIV at a little scale, and desire all in their city to recall their existence, for our civil buildings of old date, let us say that they have become very rare, and it is not surprising that the people have lost even memory of them. Still it would have been very strange if men capable of conceiving and executing such vast religious edifices would be contented for the ordinary needs of life with little buildings of small extent, low height and narrow, a sort of huts of mean appearance. There are certain persons that would make us believe, because of the spirit of a system, that we do not have to crit-

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criticize here, because it is entirely foreign to the ideas of art, that the society of the middle ages was restricted to the church and the fortress; that it was consequently unable to conceive and execute those great establishments of public utility demanded by our modern customs; finally that it lived miserably, suppressed by a twofold oppression, often rivals, but always united to arrest its development. From the political point of view, the fact can be discussed, but it is not our affair; yet from the point of view of art, it cannot be sustained. The artists that drew the plans of our cathedrals were not embarrassed, when required to construct those great civil establishments, such as hospitals, colleges, city halls, markets, farm buildings amply provided with all their services. As architects it is of little importance to know whether these hospitals, colleges, farm buildings belonged to abbeys or chapters, if those city halls were frequently closed by the nobles, if those markets paid a tax to the lord of the place. Those establishments existed, and that is all we need to prove; they were well arranged, well built in a durable and wise manner, which is all that is necessary to recognize.<sup>1</sup>

Note 1.p.222. One can understand the spirit of passion that caused the destruction of castles and even of churches; but what is more difficult to explain is the blind mania, that has caused the demolition in France during sixty years of such a quantity of very good civil buildings, very beautiful and useful, merely because they were old, that they recalled another age, to replace them by deplorable structures, and that cost dear although build with parsimony, and that were often very ugly. Many cities were thus deprived of establishments, that could have satisfied new needs, which attracted notice of travelers, and which on the whole did them honor.

Let us take some examples; let us examine the beautiful arrangements of the great halls of the abbeys of Ourscamp, S. Jean-des-Vignes of Soissons, Mont-S. Michel-en-mer, of the hospitals of Angers,<sup>1</sup> Chartres, which date from the end of the 12 th and beginning of the 13 th centuries. Where shall we find better constructions, better conceived, grander, more sanitary, yet without luxury, and that give a higher idea of the knowledge and the practical sense of the architects? The entirety and the details of some of these vast buildings being

and, that the society of the middle ages was restricted  
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 it includes not the smallest part of the architecture of the  
 activity and the details of some of these buildings.

engraved with minute care in the work of M. Verdier on civil architecture, we do not believe it necessary to reproduce them here; we shall give our readers some structures, that have not yet been studied, and that have an importance at least equal to those. There exists in the abbey of S. Marie of Breteuil a vast building flanked by four turrets with battlements, which could at need be defended. Its ground story contained the kitchens and their dependances. The second story contained the dormitories of the guests of the monastery; the third the great infirmary; the fourth the storerooms of provisions, and the fifth beneath the roof was a granary for grain. A lateral stairway passing through buttresses and covered by a shed roof extended to the third story, the angle turrets also had screw stairs communicating from one story to another. This building was vaulted only in the ground story and under the roofs; it was divided lengthwise by a row of piers. Lateral buttresses opposed the thrust of the vaults. Here (123) is the appearance of that building externally.<sup>2</sup> We see the gable against which is the great fireplace of the kitchen. A triangular buttress strengthens this gable wall at the chimney flue. To properly seize this construction, it is necessary to refer to the plan (123 bis) taken at the level of the ground story. The entire space A A, i.e., the last bay of the hall, is occupied by the fireplace, whose flue rises between two arches at B. At C are the external openings communicating by a splayed hole with the air inlets D designed to act vigorously on the fire placed on raised grates, and to establish a current of a air sufficient to carry the smoke into the central flue. Fig. 123 ter, made on the line I K of the plan indicates to us at B the chimney flue, at C being the dotted openings, and at D the blow holes. One will note that the passage along the battlements is not interrupted by the turrets and gables, but on the contrary this passage remains at a lower level at the gables. Fig. 123 quater indicates at A the section of the ground story on the line E F of the plan, and at B this section on the line G H. In section A are seen at C the arches that form the mantle of the fireplace divided by the great pier, at D are the mantles of the blow holes with the raised grates. In section B the arches M that form the vault of the fireplace are of brick, and the flue is dotted at O. A dotted line like-



likewise indicates the two air inlets P intended to supply the blow holes by the opening behind the partition wall forming the back of the chimney. The section (124) made across the building and looking toward the gable opposite the fireplace, completes this beautiful and simple structure. There is seen at A the lateral stairway ascending to the third story through the buttresses, increased by a projection to allow it to pass. The windows B of the fourth story serving as a storehouse are pierced in the gable at the level of the internal floor, so as to facilitate the hoisting of stored articles by pullies and external cranes. It is the same with the doorways C opened at the level of the fourth floor of the granary. The side walls are thick and maintain a uniform temperature in the interior, the ventilation of the stories can readily occur by means of windows opened in the four sides of the building isolated from all parts. The buttresses stiffening the walls avoided all transverse tying, and that so much the better as the internal faces of the walls were set to overhang in each story as indicated by the horizontal section, Fig. 124. That was a means frequently employed to cause the walls to incline toward each other inside, and it is indeed an excellent principle of construction, when one can give the base of the walls a sufficient thickness to not fear bending. further it is necessary to remark, that usually the intermediate floors do not connect the eave walls (see cross section); for observe how the spans of these floors are arranged on the intermediate walls. At each story the piers have a cap A (125), projecting only under the beams. Then it was necessary for these eave walls to press against these beams and not produce tension. One cannot adopt that method in structures, but it is not without its advantages, and much before the epoch occupying us, the Greeks of antiquity had followed it in erecting their temples. If in great vaulted structures borne on isolated piers, the architects of the middle ages followed the laws of equilibrium, whose importance we have tried to make appreciated, they at the same time sought to obtain concentration, the combination of all active forces at the centre of their edifices, so that all parts might have a certain tendency to reciprocally abut each other. In civil structures, where vaults only play a secondary part, where the floors offer

The main entrance to the building is located on the north side of the building. The entrance is a large, arched doorway. The building is made of brick and has a flat roof. The building is surrounded by a low wall. The building is located on a street. The building is a two-story building. The building is a commercial building. The building is a public building. The building is a government building. The building is a school building. The building is a church building. The building is a hospital building. The building is a university building. The building is a museum building. The building is a library building. The building is a theater building. The building is a concert hall building. The building is a sports building. The building is a shopping building. The building is a residential building. The building is a hotel building. The building is a restaurant building. The building is a bar building. The building is a nightclub building. The building is a casino building. The building is a gambling building. The building is a prostitution building. The building is a drug building. The building is a crime building. The building is a terrorism building. The building is a war building. The building is a peace building. The building is a justice building. The building is a law building. The building is a court building. The building is a prison building. The building is a police building. The building is a fire building. The building is a ambulance building. The building is a hospital building. The building is a university building. The building is a museum building. The building is a library building. The building is a theater building. The building is a concert hall building. The building is a sports building. The building is a shopping building. The building is a residential building. The building is a hotel building. The building is a restaurant building. The building is a bar building. The building is a nightclub building. The building is a casino building. The building is a gambling building. The building is a prostitution building. The building is a drug building. The building is a crime building. The building is a terrorism building. The building is a war building. The building is a peace building. The building is a justice building. The building is a law building. The building is a court building. The building is a prison building. The building is a police building. The building is a fire building. The building is a ambulance building.

horizontal and rigid floors at different heights, the constructors adopted methods of building from outside inward against these rigid surfaces. They attained that result by general arrangements and by procedures belonging to the details of construction. For example, they gave the walls projections beyond each other inside, as we have just stated, and they built these walls of great stones externally and of low courses or rubble inside.

Note 1.p.223. See Arch. civ. et dom. of Aymar Verdier & Cottolais.

Note 2.p.223. See Monog. d'abbayes. Lib. S. Genevieve.

Assume the section of a wall A B destined to support floors (126), the external surface of this wall will be composed of high courses of stone not extended through, and each story b being separated by a stone band will be recessed an inch or so behind the next beneath. On the contrary the internal surface will be built of lower stories and will have a projection beyond that below. Thus this wall will have a tendency to incline from the exterior inward, 1, because its axis B falls at B' inside the lower axis A; 2, because the external surface will be less compressed than the internal one. Then this wall so built will exert against the ends of the beams C a pressure, the more powerful the higher these floors are elevated above the ground. Thus it will be superfluous to tie the walls together, which far from tending to separate, on the contrary will tend to incline toward the centre of the building.

It is evident from this example, that although the civil construction of the middle ages has its own character, distinct from religious construction, still the architects in both seek to replace inert masses by acting forces. In civil structures, the floors are regarded as struts set between the walls that tend to approach each other. Thus these floors are stiffened by the pressure of the walls, and the entirety of the building offers great stability because of these pressure against the struts.

The constructors of the middle ages made proof of great independence in the vaults belonging to civil edifices, the tunnel vault, the Roman cross vault, the Gothic cross vault with round or segmental arches, the vaults composed of spaced arches supporting ceilings or little vaults, all is good to them, according to the occasion and need. When in religious architec-



architecture they no longer used but a single kind of vault, i.e., during the 13<sup>th</sup> and 14<sup>th</sup> centuries, and still had the good sense not to apply this system in civil structures, whatever advantages it offered. Frequently very wide buildings required the erection of one or two rows of piers in the interior to support the floors of the upper stories, as we have seen above; then the ground story was generally vaulted; but since these superposed posts, stayed only by the floors, were not stable, men improved this in a way at least by placing them on the lower piers supporting the vaults, and fearing to crush the imposts of those vaults, made them independent of the piers.

Thus for example (127); let pier A of the ground story be intended to support the vaults; on this pier were placed two or three courses B corbelled out on the four sides; thus was obtained the bearing  $\alpha$ . At the angles were placed the imposts B on the diagonals of the square, to receive the voussoirs E of the diagonal arches of the vault; at the centre the pier C rose freely to receive the upper floors, and then the fillings H of the vaults were closed with rubble. The imposts of these vaults and its fillings received no load, and the mass forming the haunches only abutted the piers. Fearing the effects of the thrusts in the ground story on the walls, that were not always furnished with buttresses, the constructors frequently established very strong corbels along these walls, to diminish the effect of thrusts as much as possible, and to transfer their resultant to the solid wall or even to the internal surface of these walls. On these corbels they could then permit themselves to place segmental arches, so as to occupy less height. Renouncing cross vaults or pointed vaults on the great arches perpendicular to the walls (128), they built the vertical spandrils B up to the level of the extrados of the crowns of these arches A, then they turned on these spandrils tunnel vaults C also segmental. By this means they came to vault large areas without occupying much height and without dropping the springings of the arches low enough to obstruct passage. By multiplying and bringing these arches closer together they could replace the small vaults C by slabs forming a ceiling, set on stone beams (if these materials sufficed), as shown by Fig. 129. These beams were furnished with rebates,



so as to present their upper surfaces at the level of the slabs, as indicated by the dotted line E F. These methods of building were retained very late without sensible modifications, for we still see structures of the 15 th century that reproduce these severe, grand and simple arrangements. The most beautiful examples that we know of these civil structures in which the corbellings play a very important part is the castle of Hoch-Königsburg near Schlettstadt.<sup>1</sup> One could take the principal halls of this castle for constructions of the 13 th century, while they were built only in the 15 th century. But Alsace has retained, especially in civil architecture, the old traditions of the good Gothic epoch. The principal structure of the castle of Hoch-Königsburg built against the rock, (130) is composed only of internal buttresses with a very thin external wall on the side of the court. It contains four stories; the ground story, that served for kitchens, is covered by segmental vaults resting on very flat arches of rubble, turned from one pier to another. The second story is covered by great platbands relieved by powerful corbels; between the platbands the parallellograms remaining are arched with rubble. The third story is covered by a wooden floor, whose main beams rest on corbels engaged in the piers. The fourth story is covered by a round tunnel vault resting on platbands, and wide corbellings arranged like those of the second story. That upper vault bears a platform or terrace covered by slabs. The perspective section (Fig. 130) gives the whole of this singular structure. It must be stated that the material of the province lends itself to this boldness (red sandstone); one could not with our limestones of the basins of the Seine, Oise and Aisne, allow the use of lintels of such small depth and great span.<sup>1</sup> But in civil and military architecture, more than in religious architecture, the nature of the materials had a very marked influence in the use of the means of construction; this example is a proof of it. The longitudinal platbands between the buttresses and the transverse ones from one buttress to another are cut with joints. If we make a longitudinal section of this building, each bay gives us Fig. 131.<sup>2</sup> One can form an idea of the magisterial grandeur of these buildings, if he has not seen them. Here nothing is granted to luxury; this is pure construction, and the architecture has no f

and to present their most valuable at the level of the vi-  
 sion, as indicated by the dotted line F. These methods of b-  
 listing were retained very late among scientific architect-  
 ures, for we still see structures of the 15th century that re-  
 tain these methods, though not always systematically. The most  
 useful example that we have of early civil architecture in  
 the 15th century is the very important part in the north-  
 west of the Louvre, the Châtelet. It does not have the  
 logical unity of civil architecture for the construction of the 15th  
 century, which was only in the 16th century. But  
 we are interested, especially in civil architecture, the  
 construction of the 15th century. The principal sym-  
 bol of the unity of civil architecture is the unity of the  
 (15th) is expressed only in the architectural language with a very con-  
 siderable unity of the unity. It contains four main  
 parts: the ground story, the second story, the third story, and  
 the fourth story resting on very fine arches of rubble, a  
 part from one pier to another. The second story is covered  
 by a balcony relieved by powerful corbels; between the  
 second and the third story the parallel arches are covered with rubb-  
 le. The third story is covered by a wooden floor, whose main  
 part is covered by a balcony in the first. The fourth story  
 is covered by a round tunnel vault resting on pilasters, and  
 the corbels are arranged like those of the second story. The  
 vault bears a platform or terrace covered by slabs. The  
 perspective section (Fig. 140) gives the whole of this struc-  
 ture. It must be stated that the material of the ar-  
 ches lends itself to this thickness (of sandstone); one co-  
 mingles with our limestone of the basin of the Seine. One  
 must allow the use of levels of such small depth and  
 width.<sup>1</sup> But in civil and military architecture, more th-  
 an in religious architecture, the nature of the materials had  
 very marked influence in the use of the means of construction.  
 The 15th century is a period of the individual character  
 of the architecture and the construction with the 15th cen-  
 tury. The materials are not joined. If we make a longitudinal  
 section of this building, each part gives us Fig. 141.<sup>2</sup> One  
 has an idea of the material character of these build-  
 ings, if we have not seen them. Here nothing is granted to lux-  
 ury; this is pure construction, and the architecture has no

form other than that produced by the judicious use of the materials; the principal points of support of the lintels are alone of cut stone; the rest of the structure is of rubble plastered. We confess that this mode of understanding civil construction has a special attraction for us. It must be stated that the castle of Hoch-Königsburg is built on the top of a high mountain, eight months of the year in the midst of snow and fogs, and that in such a location it would have been ridiculous to seek architectural forms, that would have been appreciated only by eagles and vultures; that the savage appearance of these structures is in perfect harmony with the rugged location.

Note 1.p.233. See general plan of this castle in Art. Chateau, Figs. 30, 31; hall M.

Note 1.p.236. In the 15 th century an accident compelled the owners of the castle of Hoch-Königsburg to turn arches under the floor of the second story.

Note 2.p.236. M. Boeswilwald, who drew the castle of Hoch-Königsburg with the greatest care, was very willing to place his drawings at our disposal.

In regard to this, we allow ourselves a remark not without importance. We believe we are the first to appreciate what is termed picturesque, because the 17 th century, men no longer find beauty except in parks planted in the French manner, in aligned and symmetrical buildings, in terraces covered by stone and cascades lined with lead. Without denying the value of this nature arranged by art, still we must recognize, that nature left to itself is more varied, freer, grander and also more really beautiful. A nobleman of the court of Louis XIV or of Louis XV much preferred the parks of Versailles or of Sceaux to the wild appearance of the gorges of the Alps or Pyrenees, duke S. Simon, who had no employment at court, loved better to live in a narrow and dark apartment at Versailles, than to live in his charming residence of La Ferte. Now on the contrary our lords of the middle ages were sensitive to those natural beauties, and they loved them because they lived in their midst. Without speaking of the very vivid appreciation of nature found in the numerous romances of the middle ages, we see that the castles, manors, and the abbeys are all located so as to cause their inhabitants to enjoy the out-



outlook on their surroundings harmonizes with their locations; wild and grand in abrupt places, elegant and refined at the foot of smiling slopes, on the banks of tranquil rivers, in the midst of verdant plains. In habitations the views of the most picturesque points are always arranged with art and so as to present unexpected and varied views. When one studies the civil structures of the middle ages, it is then necessary to have regard to the place, the nature of the climate, the site, for all that exerts an influence on the constructor. A building that would be properly arranged and built on a plain, in the country with mild and tranquil appearance, would be ridiculous at the top of a savage rock surrounded by precipices. Another by its severe and even brutal character, seems to belong to the desolate soil on which it rises, but would seem deformed and rude when surrounded by meadows and orchards. Those barbarous men, to say the most, were then sensitive to natural beauties, and their habitations reflected these different kinds of beauty, so to speak, placed on harmony with them. We that are civilized, and who claim to have invented the picturesque, erect elegant pavilions on some wild site, that seems destined to support a fortress, and we build ourselves massive structures on the bank of a brook running through the meadows. That makes us believe that these barbarians of the middle ages loved and understood nature, without making a noise about it, and that we who boast of that on every occasion in prose and verse, we regard it with a distracted eye, without allowing ourselves to be penetrated by its beauties. The centuries are like individuals, they always desire one to believe them endowed with qualities that they lack, and care little for those that they possess. Everyone fought for religion in the 16<sup>th</sup> century, and nine tenths of the combatants, on one side as on the other, did not even believe in God. Men prided themselves on chivalry and fine manners in the 17<sup>th</sup> century, and already at that epoch minds turned very strongly toward positive ideas and the satisfaction of material needs. In the 18<sup>th</sup> century men spoke only of virtue, nature and mild philosophy, when virtue was scarcely in fashion, when nature was seen through the glass windows of the study, and that in fact of mild philosophy, only was practised what was based on the assured well-being of one's self and friends.

and that in a certain degree, classical and refined as the  
 most of our writers, on the banks of the great rivers, in  
 the midst of verdant plains. In habitations the views of the  
 landscape presents are almost everywhere the same, and as  
 the landscape is associated and varied views. When one settles  
 in a rural situation of the middle ages, it is then necessary  
 to have regard to the place, the nature of the climate, the  
 soil, for all these exert an influence on the character. A  
 climate that must be extremely arid and cold in a plain,  
 the country with mild and temperate appearance, would be in-  
 suitable for the top of a rugged rock, or a mountain. It  
 is therefore by its severe and even brutal character, seems  
 to be the absolute soil on which it stands, and which  
 is the most and the most arid, when surrounded by meadows and crops.  
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 the middle ages loved and understood nature, without making  
 a show of it, and that we who boast of that on every occa-  
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 about allowing ourselves to be deceived by its beauties.  
 The ancients are like individuals, they always desire one to  
 leave them endowed with qualities that they lack, and care  
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 tury, and already at least some minds turned very seriously  
 and sensitive ideas and the satisfaction of material needs.  
 The 18th century men seek only of virtue, nature and mi-  
 philosophy, when virtue was scarcely in fashion, when nat-  
 ure was then the great virtue of the 18th century, and the  
 last of all delicacy, only men understood what was meant  
 by the assured well-being of one's self and friends.

Let us return to our buildings. The system of construction by corbelling being strongly in fashion from the 12 th century in civil buildings; indeed it is economical and presents numerous resources, either for separating floors, to avoid great thickness of walls and considerable foundations, to receive carpentry, bear projections, to obtain larger areas in the upper stories of buildings than in the ground story, to provide lobbies, stairs communicating from one story to another, and offer shelter, etc. This was also an application of this principle of the architects of the middle ages, consisting in employing active instead of passive forces: for a corbelling is an overhang that requires a counterweight to retain the function that one claims to give it. Corbellings have the advantage in producing thrusts, always difficult to maintain in composite structures, like every habitation, the walls of small thickness intersecting each other irregularly, according to the purposes of the rooms. They take less height than arches, or their thrust may be neutralized by setting the imposts outside the surfaces of the walls, which is easy to prove.

Let A B (132) be the opening of a hall whose floor will be separated by arches, as shown by Figs. 128, 129; A C, B D is the thickness of the walls; C E the height between the floors. If we turn the arches G F penetrating into the walls, even admitting that we shall have a heavy load at K, there will be reason to believe that such a great thrust will be exerted from G to H, that the wall will bend to the outside, for the resistance of friction of the bed G H will not be sufficient to prevent sliding; if there is no slipping, the length G H is not such that the joint could not open outside and crush inside as shown at I, the effect that will cause the bending of the wall, and consequently the fall of the arches. But if we have a strongly projecting impost L and two corbelled courses M N, assuming a reasonable load K', we can resist slipping by a bed L O much longer and with greater friction; the curve of pressure exerted by the arch penetrating the bed L O at P will find there a component, that will be combined in a line P R, more or less inclined inversely as the greater or lesser weight of the upper load K'. If this load be very great, the point R or resultant of the thrusts may be vertical and fall within the internal surface of the wall or nearly so; that is

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...of the lower load K. If this load be very great, the  
...of resistance of the impost and the wall  
...of the wall at the base of the wall.

all that one can ask. The constructor takes care in this case to place at least one course having its internal vertical surface in the vertical through the intersection of the arch with the corbelled impost, for he thus increases the resistance of the thrust by the friction of the two beds of the stone, while if he places only a single corbelled course under the impost, as we have sketched at S, he will have for opposing the thrust only the resistance of the bed T V, and the bending of the wall may be produced at Y as it was produced at H'. When constructors for any reason could not give to their corbelling the height of three or four courses, then they obtained very resistant stones, and (133) they set these to project as indicated in section A, so that the curve of pressures of the arch falls at B inside the inner surface of the wall; then the stone A tends to tip, and they relieved it by a small projection C; its tipping movement describes a part of a circle with centre D. To resist this movement of tipping, there is the load E with the filling F in masonry. Not being able to tip, the corbelling A no longer tends except to slide from B to G. Now it is necessary to make the friction sufficiently strong on the bed D G by means of the vertical load E to prevent this slipping. Corbellings then possess two properties; the shortening of spans by means of overhands held by loads on their tails, and the action of resistance to oblique thrusts by increasing the surfaces in friction.

Thus one recognizes that in all cases the constructors of the middle ages employed active resistances, i.e., the system of equilibrium instead of the principal of passive resistance of Roman construction. Besides, as always these constructors pushed the consequences of an accepted principle to its last limits; they did not seem to know those impossibilities that our modern art opposes in the form of an academic veto to bold experiments. Construction for them is not that science which consists in saying; "Here are the rules and examples, follow them, but do not go beyond them." On the contrary, science for them said; "Here are the general principles, they are broad and indicate only the means. In application extend them as much as the materials and your experience permits you; we only ask you to remain faithful to these general principles; besides all is possible to him that knows how to apply them."



Is that a stationary and hieratic art, foreign to the modern spirit, as some claimed so long to make us believe? Is it merely to retrograde to study it, to become permeated by it? Is it the fault of that art if many only interpret it by its external appearance, compromising its development by unskilful imitations? Shall we attribute to antiquity the bad copies of its arts? Then why do we refer to the arts of the middle ages in France the false applications that one can make of them, whether in Italy before the Renaissance or among us in our time? From the moment when it was admitted that there was no architecture except in Italy, that architects have been like sheep following each other, to study art in that country, academic instruction has only wished to see the middle ages there. Now the edifices of the middle ages in Italy are structures of moderate extent, from the point of view of construction. Nearly always they are only constructions derived from Roman antiquity, clothed in a very bad exterior borrowed from the arts of the North or the East. Certainly it is not that which one should go to study beyond the mountains. As for construction, one finds neither fixed principles nor sequence, but a disorderly mass of confused traditions, of influences opposing each other, a barbaric love of luxury beside evident lack of power.<sup>1</sup> For example, what are the basilicas of Rome, mostly rebuilt in the 13th century, if compared with the edifices erected among us at that epoch? Bad brick walls, badly joined to shafts and capitals torn from antique monuments. In these barbarous structures, where are art and study? If we consider them with respect and curiosity, is this not because they present to us the spoils of magnificent edifices? If we marvel before rich jewels pillaged in a palace, does the pillage arouse our admiration? Let us then be sincere, and put the things in their true places. If the Romans of the middle ages found a soil covered by antique ruins, if still in the 13th century the baths of Antonine caracalla were standing and about intact, as well as the Coliseum, Palatine and so many other edifices, do we go to admire the works of men more barbarous than the Vandals and Huns, who coldly destroyed those monuments to erect bad structures, in which even these ruins are unskilfully employed, rudely placed in the work; we see appear there only the variety of a weak people; intelligence, ideas



and finally art are entirely wanting. What a different sight among us! Then the lay architects in France carried on their labors persistently, without thinking of their personal glory, they only sought to develop the principles that they knew how to discover; they believed the future to be before them, and this was not an illusion, for they first commenced in the modern era the great struggle of intellectual men against brute matter. The constructors of antiquity are the allies and frequently the slaves of the materials and they submit to their laws; the lay constructors of the middle ages declare themselves its antagonists, they claim that the mind must be right, that it must subjugate the latter, and that this will obey. Is it well for us, who pierce mountains to travel with more ease and more rapidly, who no longer take account of distances and defy natural phenomena, to scorn those, who by their investigating and subtle minds, their disinterested faith in principles based on reason and calculation (certainly disinterested, for scarcely any have left us their names), preceded us by several centuries, and only were wrong in appearing too soon, being too modest, and of having believed that they would be understood. It is said that history is just; that is to be desired; but its justice sometimes delays a long time. We grant that from the 12<sup>th</sup> to the 15<sup>th</sup> centuries, political society was disordered, the clergy were usurping, the feudal lords were tyrants, the kings were ambitious, sometimes supple and sometimes perfidious; Jews were usurers, and the peasants were miserable brutes, that this society was influenced by ridiculous superstitions, and cared little for morality; but we see in this chaos appear without noise a class of men neither religious, nobles nor peasants, possessing the most abstract art, that lending itself to calculations and logical developments; of the art to which everyone must resort, for it is necessary to lodge, guard and defend one's self, to build temples, houses and fortresses. We see that class attract around itself all the artisans, and subject them to its discipline. In less than a half century, this association of tireless workers has discovered principles entirely new, and that can be infinitely extended; it has introduced into all the arts analysis, reasoning and research, instead of routine and decrepit traditions; it founds schools; it marches



on without stopping for a day, isolated but orderly, tenacious and subtle in the midst of anarchy and of general indecision. It ascends the first steps of modern industry, of which we are justly proud, and because this association passes its time in work instead of writing memoirs in its praise; because its members, more careful to make their principles triumph, than to obtain personal glory, inscribe their names on some stones; that by force of research they attain even to the abuse of those principles; because that finally this association is concealed under the three last centuries, whose vanity at least equals their splendor, should we be ungrateful enough today not to recognize what we owe it, foolish enough not to profit by its labors? Why is that ingratitude and folly? Because some idle minds have made their decision, and pretend to preserve the principles of a dead art, which they avoid putting into practice, and that they do not even state clearly? Who are the retrograde minds? Are they those that condemn us to reproduce forever the incomplete or badly understood attempts made by the three last centuries to revive the architecture of the Romans, or those who seek to place in honor the resources of an art both reasoned and bold, lending itself to all the combinations and all the developments required by the varying needs of modern civilization? The scales of the history of the arts would be just if held by an impartial hand, if one did not always lay on its scales names instead of facts, individuals in place of monuments. What have we indeed to oppose to names like those of Diotis Salvi, Arnolfo di Lapo, B Brunelleschi, Michelozzo, Balthazar Peruzzi, Bramante, San M Micheli, Sansovino, Pirro Ligorio, Vignola, Ammanati, Palladio, Serlio, Jean Bullant, Pierre Lescot, Philibert Delorme, Du Cerceau, etc.? Two or three scarcely known names. But if our French monuments of the middle ages could speak; if they could give us the modest names of their authors, if above all before the works of men just cited, they could show us all the mysteries of their construction, certainly then history would render justice to them, and we should cease to be the dupes, to our injury, of a mystification lasting for more than three centuries.

Note p.241. A single example to prove that we do not exaggerate. We have seen in this Article the series of persistent ef-



efforts the constructors of the North have succeeded in making themselves masters of the thrust of vaults, and in what conditions they wished to ensure stability of these vaults. Now in Italy the spreading of the arches of monuments vaulted in the middle ages and even the Renaissance is opposed by means of iron bars placed at their imposts and remaining visible. On this account, they could well omit flying buttresses and the entire equipment of buttresses and combinations for equilibrium. Men take good care not to reproduce those iron bars in the drawings given to us, or to speak of them in works on the matter. But in truth is that a means of construction? Is it not rather a confession of weakness?

Western Europe can justly glory in having aroused the great intellectual movement of the Renaissance, and we are not of those that regret this return to the arts and knowledge of pagan antiquity. Our century comes after that of Montesquieu and of Voltaire; we do not disown those great minds, we profit by their clarity, their love of truth, reason and justice; they opened the way to criticism, and extended the domain of intelligence. But what do they teach us? Would it be by chance to compel us to reproduce forever their ideas, to conform ourselves to their personal tastes without examination, to partake their errors and their prejudices, for they are no more exempt from these than others? That would be to understand them badly. What do they say to us on each page? "Instruct yourselves, do not stop, leave aside opinions already formed, these are almost always prejudices; the mind was given to man to examine, compare, collect, and choose, but not to conclude, for the conclusion is the end, and very foolish is he that pretends to say; I have closed the human book!" Is it then the especial taste of some philosopher that must be taken as a model, or his mode of reasoning, his method? Voltaire did not love Gothic, because Gothic belonged to the middle ages, whose last prop he undermined, that proves only that he knew nothing of that art, and that he obeyed a prejudice; it was a misfortune for him, not a rule of conduct for artists. Let us endeavor to reason like him, let us bring to the study of our art his spirit of analysis and of criticism, his good sense, his ardent passion for what he believed just, if we can, and we shall come to find that the architecture of the

[illegible]

middle ages is based on novel and fruitful principles, different from those of the Romans! that these principles can be more useful today than are Roman traditions. The rare minds that have acquired in their time a great influence are like those torches, that light only the space where they are placed, they can make clearly appreciated only what surrounds them. Does that mean that there are in the world only the objects on which they cast their light? Place them elsewhere and they will cast the same light on other objects. But we are so made in France; we regard lighted objects without caring for the torch, without ever transferring it elsewhere to aid us by its light in order to examine everything. We prefer to adhere to judgments pronounced by the minds of the elect, rather than to use their mode of examining the facts, to judge for ourselves. That is in truth more consistent. We admire their boldness, the extent of their views, but we do not dare to be bold like them, to seek to see farther than they, or to see anything that they neither desired nor could see.

But we are very far from our masters of the middle ages. Let us return to them, the more that they scarcely mistrusted probably, that it would be necessary some day to spoil so much paper in their own country in an attempt to make their efforts and progress appreciated. In advance of their age by the extent of their knowledge and even more by their independence as artists; scorned by more enlightened centuries, that would not take the trouble to understand them, in truth their destiny is sad. Will the day of justice never come for them?

The needs of civil construction are much more varied than those of religious construction; hence civil architecture furnished to the architects of the middle ages opportunity to exhibit the numerous resources, that they could find in the principles to which they were subject. It is necessary to properly define these principles, for they have a great importance. The architecture of the Renaissance (not that of the Greeks, be it fully understood),<sup>1</sup> is a construction covered by a decoration, that thus becomes in fact the visible architecture. If one restores a Roman monument, two operations are necessary; the first consists in taking into account the means employed to erect the carcase, the structure or actual edifice; the second is to know how this structure has assumed a form more

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or less beautiful, or more or less well adapted to this body. We have taken into account this method elsewhere.<sup>2</sup> This system has its advantages, but it is often merely a skilful lie. One can study Roman construction independently of Roman architecture, and this proves that the artists of the Romans studied the external form without considering the body that it covered. Architecture and construction of the middle ages cannot be separated, for that architecture is nothing but the form determined by the construction itself. There is not one member of Gothic architecture, however small, at the epoch when it passed into the hands of laymen, which is not imposed by a necessity of construction, and if Gothic construction is very varied, this is because the needs to which it must submit are numerous and varied themselves. We do not hope to bring under the eyes of our readers all the applications of the system of civil construction among the peoples of the middle ages; we can no more that claim to trace in main lines the principal ways pursued by that system; for one of the most striking characters of the art as well as of the manners of the middle ages is to be individual. If one wishes to generalize, he falls into the strangest errors, in the sense that the exceptions exceed the rule; if he desires to take account of some of these exceptions, he knows not what to choose, and he restricts the study. We believe that he can emphasize the principles, which are simple and rigorous, and seek among the applications, those best and most clearly expressing these principles.

Note 1.p.245. For architects who have studied somewhat the arts of antiquity, the difference between the architectures of the Greeks and of the Romans is perfectly distinct; those two arts follow opposite paths, as we have stated many times; but for the ordinary people this is not the case, as they confound those two arts, as if one were not derived from the other. How many times has it not been said or written, for example, that the portal of S. Gervais at Paris is the portal in Greek architecture? It is scarcely more Greek than Roman. Yet on such blind judgments has the criticism of architecture been based among us for a long time, and that because we architects, perhaps by indifference, we are the only ones in France that do not write on our art.

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Note 2.p.245. See our *Entretiens sur l'Architecture*.

The several examples that we have given illustrate, we hope, the consequences of the principle adopted by the lay architects in the construction of the middle ages; appearance of the means employed in the construction of edifices, and an appearance really producing the architecture, i.e., the visible form; solutions of the given problems by the natural laws of statics, of equilibrium of forces, and by the use of materials in accordance with their properties, acceptance of all programmes, however varied, and subjecting the construction to these programmes because of the architecture itself, since this architecture is only the frankly accepted appearance of that construction. With these settled principles, with some examples selected among the applications of these principles, there is no architect that could not construct like the masters of the middle ages, proceed like them and vary the forms according to the novel needs, that perpetually arise in the midst of society like ours, since each new need must incite a new application of the principle. If we are accused of desiring to cause our art to retrograde, it is well at least that you should know how we intend to bring it back; the conclusion of all that we have said being:— "Be true." If truth be a sign of barbarism or ignorance, we should be happy to be relegated among the barbarous and ignorant, and proud of having led some of our colleagues with us.

Corbellings play an important part in civil structures, for which we have given the reason above; it remains to pursue a the varied applications of that method. There exists in the part of Champagne adjoining Burgundy, and vice versa, houses otherwise very simple, built during the 13<sup>th</sup> and 14<sup>th</sup> centuries, that have a gable on the street, and consist externally of a sort of porch with balcony above, sheltered by a very projecting roof. The entire system only consists of corbellings skilfully combined. Thus (134) the eave walls support a first corbelling at right angles, designed to support a beam receiving the ends of the joists of the floor of the second story also resting on the rear wall. This beam is surmounted by a railing. A second corbel A gives the eave walls a projection that protects the balcony and receives a gable truss arranged to support the floor of the attic, and to permit taking prov-



provisions into that attic. The wall thus set back vertically over the wall of the ground story is only a wooden partition. Note that the second corbel - (134 bis) leaves above its last course H a portion of the vertical wall H I, so as to load the tails of the corbel stones by a mass of masonry. Behind it is the half timber wall G, which encloses the second story. To avoid all chance of the overturning of the corbelled mass, the double plates N that carry the roof and crown the entire lengths of the eave walls, have at their ends strong keys O, that maintain the heads of the corbels. That very simple arrangement is found in many peasants' houses. (Art. Maison).

But let us see how in the richer buildings, more complicated and more important, the constructors came to use the corbellings with skill, submitting to the arrangements required by a particular need. It concerned the opening of a doorway in the reentrant angle formed by two buildings intersecting at a right angle, a very convenient arrangement also, and that was often demanded by the occupants of a manor or of a house; to allow the doorway to give entrance to the halls of the ground floor at right and left, and then in the second story; to suppress that cut-off angle in which the door was opened, to recover the right angle formed by the intersection of the two walls, that at least one of the two extends in a dividing wall, and to then establish above that doorway and in the reentrant angle a service stairs communicating from the second to the upper stories. By means of ironwork covered with plaster, one can easily satisfy the programme today. But if it is necessary to not lie in the construction, the matter becomes less easy. Then let (135) be the plan of the ground story of that construction and plan B be that of the second story. One sees at C the door opened in the cut-off angle; at D are the internal piers; at E is the horizontal projection of the external corbel supporting the reentrant angle, and at F is the horizontal projection of the corbels supporting the projecting angle; G G are arches abutting the reentrant angles and supporting the division walls of the second story. We present (136) the external view of the doorway with the corbels, that serve as a hood and bear the projecting angle of the service stairs traced on the plan B of the second story. Even if necessary, these corbels can mask a machicolation destined to defend the doorway.



Fig. 137 gives the internal view of the porch with corbels supporting the reentrant angle; at G are the two arches abutting these corbels and supporting the upper division walls. The newel of the stairs rises over the middle of the cut-off corner, and the internal and external corbels are maintained in equilibrium by the opposed weights of the two projecting angles of the enclosure of that stairs. Men have since desired to obtain similar results by means of trumpets; but these trumpets load the lower masonry much more than the system of corbels, require more and larger materials, stonecutting difficult to draw and still more to execute. That is therefore not an advance, unless one regards as an advance the pleasure given to a stonecutter to show his knowledge at the expense of the purse of whoever builds.

If during the 14<sup>th</sup> and 15<sup>th</sup> centuries, religious structures modified but little the methods applied to the art of building by the architects of the 13<sup>th</sup> century, it is not the same in civil structures. These assume a franker charm; the procedures employed are more extended and the methods more varied; the architects make proof of that independence lacking to them in religious monuments. Already indeed life withdrew from religious architecture and carried all its energy into civil structures. Under the reigns of Charles V and of Charles VI, the development of architecture applied to public edifices, to castles and houses, is very rapid. No difficulty arrested the constructor, and by extending the principles adopted by his predecessors, he came to execute the boldest structures, and best understood from the double point of view of stability and of art. At that epoch some lords knew how to give an unusual impulse to constructions, then loved them,<sup>as</sup> it is necessary to love them, leaving to the artist entire liberty in the means of execution and the character appropriate to each building.<sup>1</sup> The dukes of Burgundy and Louis of Orleans, brother of Charles VI, caused to be erected residences, half fortresses and half pleasure palaces, that indicate in the artists to whom were entrusted these works, an experience and rare knowledge, at the same time as a perfect taste; in the lords that ordered these works, a wise and well understood liberality, which since then is scarcely a quality peculiar to personages wealthy and powerful enough to undertake great struct-



structures. If Louis of Orleans was a great spender of public funds, if he abused the state of lunacy into which his brother the king had fallen, it must be recognized, that as a great lord with immense wealth, he built like a man of taste. He almost entirely rebuilt the castle of Coucy, erected the residences of Pierrefonds, of Ferte-Milan, and enlarged those of Crepy and of Bethisy. All these structures undertaken under the orders of that prince were of a rare execution and beauty. One finds there what it is so difficult to combined in the same edifice, perfect stability, strength with elegance, and that richness and good good quality, that leaves nothing to caprices. From this point of view the buildings of Coucy erected about 1400 have all the serious dignity of Roman structures, all the grace of the most delicate conceptions of the Renaissance. Leaving aside the style of that epoch, one is obliged to recognize in the architects of that time a very marked superiority over those of the 16th century as constructors, their conceptions are broader, and their means of execution are more secure and wiser. They know better how to subordinate the details to the whole and built more solidly. The great hall of the castle of Coucy, called hall of the knights, was a perfect work (Art. Salle); We shall show here only certain parts of it pertaining more particularly to the object of this Article. That hall rose in the second story over the ground story, whose vaults rested on a row of columns and on lateral walls. It was not less than 52.5 ft. wide with a length of 196.9 ft.; i.e., it could easily contain 2000 persons. At one side it received light from the country through the thick curtains of the castle; on the other from the internal court. (Art. Chateau, Figs. 16, 17). Two enormous fireplaces warmed it, and the lateral openings were six in number, three on the outside and three on the court, without counting an immense window opened at the South beneath the wooden vault. The side openings were surmounted by dormers intersecting the roof. Here (138) is the section of that hall taken through one of the side windows with the dormer opened above it, and (139) is the perspective view of the interior of that window, that has a jamb not less than 13.1 ft. wide. The platband covering it is cut in 10 voussoirs, set with great care, which are held by the curtains not less than 13.1 ft. thick, and are



maintained horizontally without the aid of any ironwork. In the perspective view, we have assumed the roof removed at A, so as to show the construction of the dormer from the interior. These dormers (see the section) open on the broad external covered way with battlements, so that at need the men posted on this defensive gallery could speak to persons placed in the hall. The defenders were covered by a little roof placed on the battlements and on isolated diers -. Daylight entered without obstruction into the hall by the dormers, and this construction is on such a great scale, that from the hall at B one could not see the top of the roof of the defensive gallery, as shown by the dotted line B C.<sup>1</sup> No trace now remains of the carpentry, and today one finds in place of that beautiful construction only the windows of the lower part of the dormers; which further suffices to give an idea of the grandeur of the arrangements adopted. In the hall of the knights (or Prussians) belonging to the same castle, we still see the windows whose jambs are covered by arches, as indicated in Fig. 140, so as to bear a considerable weight of masonry. The imposts of the doubled discharging arch advance to the intersection of the splay with the jambs A (see plan) of the window, so as to avoid skew cutting of the voussoirs, whose intradoses are thus parallel to each other. The upper arch alone extends to the exterior and completely relieves the lintel.

Note 1.p.252. Nothing seems to us more disastrous and ridiculous than to desire, as occurs but too frequently today, to impose on architects anything but the programmes, nothing gives a more gloomy idea of the state of the arts and of those professing them, than to see the artists accept all the extravagances imposed by persons ignorant of practice, under the pretext that they pay for them. Tailors on this account have more moral worth than many architects; for a good tailor, if one orders from him a ridiculous garment, would say: - "I cannot make a garment that would disgrace my house and would make men laugh at you." This evil already dates far back, for our good Philibert Delorme wrote about 1575: - "I tell you, that for thirty years and more, I have observed in various places, that the best part of those, that have built or desired to erect buildings, have commenced them suddenly, after having slightly deliberated on them; which is most frequently followed



by repentance and derision, that always accompany those badly advised, so that those thinking to understand well what they would do, have desired the opposite of what they could and should do well. And if by chance they ask from some one advice on their considerations and enterprises, this would be a master mason or carpenter, a notary, and others asserting themselves to be very skilful, most generally scarcely having better judgment or advice, than those asking it from them. Many times I have seen great personages, who decide themselves, because most of those about them never wish to contradict them, desiring to please them, or indeed because they do not understand it, and reply at once, "That is well said, Monsieur: this is a beautiful invention, that is well found, and you show well that you have a very fine understanding; never will be seen such a work in the world." But the bad persons think just the contrary, and speak it privately, perhaps otherwise. That is how some lords deceive themselves and are satisfied with their works." We could cite the entire first six chapters of the first six chapters of the treatise of Philibert Delorme; we refer our readers to it as a masterpiece of good sense, reason, wisdom and honesty.

Note 1.p.256. These great halls were usually paved with stone slabs; these were washed doily, the gargoyles were reserved for the discharge of the water. "The blood of the victims ran from all parts and streamed through the openings made near the thresholds of the doorways." Nibelungen Lied. 35 th adventure.

But it is unnecessary to state that the constructors employed this strength of means only in very considerable buildings, that must resist less the effect of time than the complex destruction by men. It even seems that in interiors of castles, where one could not fear attack, the architects wished to distract the eyes of the inhabitants by very elegant and light constructions. It is known that Charles V caused to be made in the Louvre at Paris a stairway and galleries, that passed for masterpieces of the art of building, and that attracted the admiration of all connoisseurs until the moment when these precious structures were destroyed. Especially the stairways, which present numberless difficulties to constructors, excited the emulation of the architects of the middle ages.

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There was no lord that did not desire to have a stairway more elegant and better designed than his neighbor, and indeed the little that remains to us of these indispensable accessories of the castles always indicates a certain research as well as great skill in the art of designing. (Art. Escalier).

For more modest habitations, those of the citizens of cities, their construction also became during the 14 th and 15 th centuries lighter and more labored. Then men commenced to wish to open very large windows on the public street, the more necessary as the streets were narrow, that men skilfully combined wood with stone or brick; that they sought to gain space in interiors by diminishing the points of support, by encroaching on the public way by projections given to the upper stories; that consequently the constructors were led to return to half timber work on the facade.

We do not wish to extend beyond measure this Article, already very long, and to give here examples that find their places in the other Articles of the Dictionary; we have only tried to show the profound differences separating civil from religious construction in the Middle ages. Our readers will indeed refer for more ample details to Arts. Boutique, Charpente, Cheneau, Egout, Escalier, Fenetre, Fontaine, Galerie, Maison, Pan-de-Bois, Plancher, Pont, Porte, etc.

#### CONSTRUCTIONS MILITAIRES. Military Structures.

Between the military structures of the first times of the middle ages and Roman structures, one cannot state that less perfection was employed in the use of the materials and the execution; the procedures are the same; the curtains and towers are only composed of masses of concrete faced with small rubble or a very little dressed ashlar. It seems that the Normans first applied in the execution of military works certain improvements before unknown to them, and that mave after the 11 th century a marked superiority to those structures or over those existing on the soil of western Europe. One of the most notable improvements was the rapidity with which they built their fortresses. Willian the Conqueror in a few years covered England and a part of Normandy with strong castles of masonry, executed with perfect solidity, since we find a great number of them standing today. It is to be believed, that the Normans settled on the western soil employed procedures



used by the Romans, i.e., levies for building their fortresses, and in a country entirely subjected, this is the most suitable means for erecting vast structures, that only require a considerable mass of materials and many men. Besides one does not find any trace of art in the primitive military structures of the Normans, all is sacrificed to the material need of defense. This sort of structures have nothing that can furnish material for analysis; they have an interest only from the point of view of defense, and in that respect their arrangement is found described in Arts. Architecture Militaire, C Chateau, Donjon, Tour.

It is scarcely before the end of the 12 th century, that we see employed procedures in construction peculiar to defensive works, forming a separate art. For massive concrete opposing an equal and continuous resistance were substituted points of support connected by discharging arches, thus forming in the curtains as in the towers points more resistant than others, independent of each other, so as to avoid the fall of great parts of masonry, if they were undermined. Then also was attached a great importance to the sites of military works, so that constructors chose rocky soils difficult to penetrate by mining, and that they frequently cut the rock itself to obtain indestructible precipices, that indeed during the great sieges undertaken at that epoch, notably by Philip August, the sap and the mine were the means most commonly employed to overthrow the walls. (Art. Siege).

One of the reliefs that decorates the western facade of Notre Dame la-Grande at Poitiers, and that dates from the beginning of the 12 th century, already represents to us the walls of a city composed of discharging arches resting on slightly projecting external buttresses (141). But it is necessary not to rely too much on those representations of monuments, that are not always conformed to the reality. When discharging arches exist, they are ordinarily apparent on the interior of the walls and support the defensive gallery, and are masked by the external surface. Simple good sense indicates, that discharging arches on the exterior indicated to the assailants the points to undermine, and that the projections of the buttresses concealed the pioneers. Then one must regard this example as the reverse of the wall for the needs of sculptured ornamentation.



The intellect that we see displayed by French constructors about the end of the 12 th century in religious and civil edifices occurs again in the military structures; they think of replacing the passive forces of Roman construction by active forces; but in military architecture, it is not only to resist external forces and the natural laws of gravity, but to oppose a resistance to the destructive hands of men. The logic of the artists who developed the art of architecture in the middle ages, and made it leave the arts of the Romanesque, is rigorous; we have had occasion to demonstrate this to our readers in the two first parts of this Article; it will be understood that this logical and true mind found a fine opportunity to exert itself in the construction of military edifices, where all must be sacrificed to the needs of defense. Sap and mining practised by means of struts to which fire was set, being the principle of the most common attacks in the 12 th century, it was necessary to oppose to this principle a system capable of making useless the works of the assailants. If then we erect a tower according to the plan A, and the miners attach themselves to the two near points of the outer surface, (142), and excavate the two holes B C, placing in them little posts, when they set fire to these posts the entire portion E F of the tower will fall outward and the work will be destroyed; but if by using the same volume of materials and occupying the same area of solids, we take care to erect, instead of a solid wall, a series of niches between internal buttresses as indicated in plan G, there is an equal chance that the miner will come below a void, instead of under a solid, and then his work and burned struts will produce no results; but if he attaches himself beneath a solid, that offering greater thickness than in plan A, his work will be long and more difficult; the recesses also allow countermining, if he works beneath those niches. Further the niches H can themselves be supported by struts inside, so as to render impossible the fall of a part of the tower, assuming that the holes of the mine are made at I and K under the piers. Thus already about the end of the 12 th century, with a volume of materials equal to or even less than that previously employed, military constructors had come to give a much stronger site to their works. Further, the constructors inserted in the thickness of the walls



large timbers held together by iron pins, to encircle their towers at different heights. The principle was excellent, but the means was very bad; for these timbers were entirely deprived of air, rapidly heated and decayed. Later was perceived the very quick destruction of these timbers, and they were supplemented by ties composed of iron cramps fixed in the beds of the courses. (Art. Chainage).

There is one remark that everyone can make, and which cannot fail to be interesting. Mortars generally employed during the 12<sup>th</sup> and beginning of the 13<sup>th</sup> centuries, in churches and most religious structures, are bad, lack body, are unequally mixed, even the sand often being wanting and replaced by stone dust, while mortars employed in military structures at that epoch, as well as before and after, are excellent and frequently equal Roman mortars; it is the same with the materials. Stones employed in fortification are of superior quality, well chosen and quarried in large blocks; on the contrary is emphasized great negligence or bad economy in most religious structures. Evidently when the lay nobles caused the building of fortresses, they had retained the Roman system of levies of supplies that the abbots and bishops would not or could not maintain. It seems that the Norman lords were the first to reorganize the system of labor on buildings employed by the Romans,<sup>1</sup> and their example had been followed in all the provinces of the North and West. Enthusiasm produced great things, but its duration was brief. It was a feeling of reaction against barbarism, that had caused the erection of the abbey churches and the vast structures surrounding them, and a desire of liberty of movement and faith, that had caused the building of the cathedrals (Art. Cathedrale); but when these moments of effervescence had passed, the abbots and bishops found only a chilled devotion; consequently negligence or deception in the execution of the works. With the lay nobles it could not be thus; they did not demand devotion from the peasants, but required from them levies regularly made under inflexible supervision. This method was certainly better for executing large works. Hence we should not be surprised by that hatred of feudal fortresses transmitted among us from generation to generation, and the affection that the people had retained for centuries for their cathedrals. At the end of the last (18<sup>th</sup>)

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century many churches were indeed destroyed, particularly monastic churches, because they belonged with feudal establishments; but cathedrals were scarcely destroyed, while all castles were devastated without exception, and many had even been ruined under Louis XIII and Louis XIV. For us constructors, who have only to state facts here, that everyone can deduce the consequences according to his way of seeing things, we are obliged to recognize that from the point of view of labor and material, one finds in the fortresses of the middle ages an uniformity and certainty of execution, a regular procedure and an attention, that is lacking in many of our religious edifices.

Note 1. p. 261. In Normandy there existed during the middle ages a class of peasants placed under the general name of tenants (bordiers). The tenants were subject to the hardest labors, and among others to labor on buildings, such as transportation of materials, earthwork, etc.; in brief, they helped the masons. (See *Etud. sur la cond. de la classe agric. en N Normandie au moy. âge*, by Leop. Delisle. 1851. p. 15, 20, 79, 83, and notes on p. 709).

In the construction of churches one notes interruptions, experiments, frequent modifications of the original projects; which are explained by lack of money, more or less lively zeal of the bishops, chapters and abbots, the new ideas that arose in the minds of those that ordered and paid for the work. All that is benevolently placed to the account of the ignorance of the masters of works, and the weakness of their modes of execution.<sup>1</sup> But when a powerful lord desired to have a fortress erected, he was not reduced to solicit gifts from his vassals, to warm the zeal of the lukewarm, and to trust to time and his successors to complete what he undertook. He desired his castle during his life, and it was a pressing and immediate necessity. Nothing troubled Richard Lionheart when he desired to erect a fortress at Andelys, a castle Gaillard, neither usurpations, sacrifices, violence nor money; he commenced the erection of the place in spite of the archbishop of Rouen, although the city of Andelys belonged to the latter. Normandy was placed under an interdict at the instigation of the king of France. The matter was carried to the feet of the Pope, who concluded an indemnity in favor of the prelate and



raised the interdict. But during these protests, threats and discussions, Richard lost not a day; he was there supervising and hastening the workmen; his fortress arose and was well built within one year, the mountain and ditches cut, the place in a complete state of defense, and one of the strongest in the North of France. When Enguerrand III caused the erection of the castle of Coucy, this was in the foresight of an approaching and terrible struggle with his sovereign. A month of delay might have stranded his ambitious projects, so one can still see today that the enormous works executed under his supervision were carried on with surprising rapidity, one that allowed no negligence. From base to summit, these are the same materials and the same mortar, and even better, the same marks of workmen; we have counted more than a hundred of these on the surfaces still visible. Now each workman's mark belonged to one stonecutter, as still today in Burgundy, Auvergne, Lyonnais, etc.<sup>1</sup> A hundred stonecutters in our days give the following proportions of the other kinds of workmen, assuming a structure similar to that of Enguerrand III.

Stonecutters.	100.
Draftsmen, detailers, foremen and transportation.	20.
Movers, hoisters and setters.	100.
Diggers, laborers, tanners.	200.
Masons and helpers.	200.
Quarrymen and limeburners.	100.
Haulers of sand.	25.
Wagoners and helpers.	50
Total,	795

Or in round numbers, 800 men.

Note 1.p.262. For example, men do not fail to state that two centuries were spent in building such a cathedral, without thinking that in these two hundred years, work proceeded only during ten or twenty years.

Note 1.p.263. The marks cut on the visible surface by the stonecutters were made to permit the foreman of the yard to verify the work of each man; these marks prove that the work was paid for by the piece, the task and not by the day (Art. Corporation), further they give the number of workmen employed, since each had his own mark.

Eight hundred workmen occupied with the masonry alone assu-



assumes a nearly equal number of carpenters, smiths, plumbers, roofers, pavers, joiners and painters (for all the interiors of the castle of Coucy were painted on fresh plastering). One may then admit that at least 1600 workers labored on the construction of that fortress. And if we examine the construction of the edifice; the uniformity of the cutting and setting, the perfect unity of the conception in its entirety and details, uniformity of the mouldings, indicate a rapidity of execution, that rivals what we see done in our days. Such activity ended in results as perfect in regard to execution, that are only exceptionally found in religious structures, as for example on the facade of Notre Dame of Paris, in the substructures of the cathedral of Rheims, and in the nave of the cathedral of Amiens. But these are special cases, while in the fortresses of the middle ages from the 12<sup>th</sup> to the 15<sup>th</sup> centuries, one always finds traces of that haste at the same time as excellent execution, well conceived plans and studied details, no experiments nor indecision.

For example, let us take one of the angle towers of the castle of Coucy, that each have 49.2 ft. diameter outside, not including the lower slopes. Each of these towers contains five stories and the story of the roof. The lower story, whose floor is a little above the external ground, has a segmental domical vault between the walls, with a thickness of about 11.5 ft. plus the bottom slope. Above that story, which is only a cellar intended for provisions, rises a story with cross vault with six sides internally. The other stories are covered by floors. Here (143) are the superposed plans of the stories above the cellar. The piers of the hexagon are set alternately, solids above voids, so that in perspective section we see the piers rise above the crowns of the pointed arches forming niches between the piers, as indicated in Fig. 144. This construction avoids the separation, that might be produced and is ordinarily produced in a cylinder containing niches opened over each other; it also permits opening slots alternately covering all points of the horizon. We assume as destroyed the vault of the lower story over the cellar in order to allow the entirety of the construction to be seen. One can descend into that cellar only by the opening pierced at the crown of the vault. It is understood now such a structure, r



resting on a solid mass and on a lower story whose cylindrical walls are very thick and are reinforced by an external slope, strengthened in each story by means of alternating piers, must defy all efforts of undermining; for to overthrow a tower built thus, it would have been necessary to undermine half its diameter, which was not easy to execute at the top of a precipice, and in presence of a garrison possessing subterranean exits to the exterior.

Let us now examine the construction of the keep of Coucy, built by Enguerrand III about 1225. This is a cylinder more than 98.4 ft. diameter outside with a height of 196.9 ft. It contains three vaulted stories of 42.7 ft. height each and a platform with battlements. The floor of the ground story is 16.4 ft. above the bottom of the ditch, and from this internal floor to the pavement of the ditch, the cylinder has a conical batter. The masonry is solid for the height of the two lower stories and is 18.0 ft. thick, and is further strengthened by internal piers forming 12 buttresses supporting the springings of the vaults. (Art. Donjon).

Fig. 145 gives the section of that enormous tower. The lower niches are shored at mid-height by arches A forming recesses made above the floor, suitable for classifying arms and machines. In the second story the niches between the buttresses rise to the vault, and their arches are its side arches. In the third story the construction could be lighter; so the cylinder recedes in the interior to form a raised gallery B allowing a very great number of persons to assemble in the upper hall. But it is necessary to explain the remarkable construction of that gallery. In plan one fourth of this story of the keep is presented by Fig. 146. On the twelve piers A B rest the transverse arches of the crown C taking the places of side arches for the great central vault D. Those piers A B have their side surfaces parallel. From points b are turned other transverse arches G parallel to the arches C, but more open, and whose imposts penetrate the skew surfaces of the piers. On the transverse arches C and G are turned pointed tunnel vaults E F. Other tunnel vaults I K parallel to the sides L of the polygon with 24 sides rest on the piers e, on the faces M' on the corbelled projections O. The perspective section seen from the point P is given by Fig. 146 bis, which



explains the intersections of the arches and tunnel vaults with these skew vertical surfaces.

The plan Fig. 146 and the perspective section Fig. 156 bis show clearly enough that at the beginning of the 13<sup>th</sup> century the architects were familiar with the most complex combinations of vaults, and that they knew how to vary the arrangements according to the needs. These are no longer religious constructions. These buttresses that project to powerfully strengthen the external cylinder and abut it by means of the tunnel vaults I K of the plan 146, indicate a very wise observation of the effects, that might be produced in such structures; and indeed although the engineer Metezau loaded a mine chamber at the centre of the keep and blew it up, he only succeeded in blowing the vaults into the air and cracking the tower at three points in its diameter without overthrowing it. The enormous cylinder produced the effect of a tube charged with powder and throwing out the vaults like shrapnel. This upper gallery supported a broad defensive gallery D (Fig. 145) open to the sky, and the central vault was covered with lead.

At E (same Fig.) are wooden ties 11.8 ins. square forming a double dodecagon at each story, and connected to radial ties K also of wood, that join at the centre of the vault by crossing. The three central vaults are each composed of 12 round ribs with side arches, whose crowns are placed at the level of the central crown; the triangles between the 12 ribs are constructed in the usual manner. Thus each of the 12 bays being very narrow in comparison to the diameter of the vault, it results that the ribs carry only the walls radiating to about two thirds of the vault, and that this central construction being very light, yet produces a powerful stiffening at the centre of the cylinder. There is no system of vaults but Gothic, that can offer such favorable arrangements, which it is necessary to recognize. From top to bottom, the work is constructed of cut stone 1.3 to 1.5 ft. high, whose surfaces are cut with straight edges, freely but perfectly dressed. As the art of attack of places became more methodical, military structures were perfected, the materials employed were larger and better chosen, the walls thicker and better built, the masses filled with greater care and the mortar more uniform and hard. During the 13<sup>th</sup> century, military structures were

During the construction of the bridge and tunnel various  
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 cylinder. Cylinder produced the effect of a true canister.  
 of water and turning out the water like a funnel. This  
 and finally produced a great defensive effect (fig. 12).  
 in the plan view, and the central vessel was covered with lead.  
 (fig. 12) are welded into 12 in. square forming  
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 and better used in the century, military structures were

executed with the greatest care, and the means of resistance opposed to attacks were remarkably extended. Men most frequently renounced surfaces of small stones or of common rubble during the 11 th and 12 th centuries; they were made of hard cut stone with tails long enough to not be easily torn out by the crowbars or pickaxes of the pioneers. In the masses are frequently found ties of stone and discharging arches embedded in the solid masonry. The parapets are composed of through stones, their external surfaces being admirably cut. Until about 1240 it frequently occurred that the courses were set on very thick beds of mortar (1.6 to 2.0 ins) fitted with bits of hard stone (147); but this procedure, that gave the beds of the courses great adhesion because of the quantity of mortar used,<sup>1</sup> had the inconvenience of aiding the pioneers to insert crowbars between the courses to loosen the stones. On the contrary after that epoch, the beds forming the surfaces of fortifications are thin (about 0.4 in. and sometimes less), the edges of the stones are sharp without bevels, and their rough faces often form projecting bosses to conceal the chiseling of the beds and joints. (148). Indeed it was difficult to break out stones so surfaced, either by means of undermining or by the battering ram or all machines suited to batter the walls.

Note 1.p.270. It is necessary to remark here, that the mortar has greater cohesive strength when occurring in a great mass, a very thin bed of mortar is burned (as the masons say) by the stone, and is then only a powdery and cracked layer without adhesion, because in setting the stones these rapidly absorb the water contained in the mortar, so that this dries too quickly and loses its properties.

Under Philip the Bold and Philip the Fair, military structures returned to antique traditions. We have seen how the constructors of the castle of Enguerrand III at Coucy adopted for the towers a thick external wall, and how internally they adopted arrangements sufficiently light to support the vaults or floors, thin piers forming between them small recesses with pointed vaults, thus they seemed to desire to harmonize the needs of defense with the new methods of building of the lay architects of the beginning of the 13 th century. If in religious and civil structures these new principles, explained in the beginning of this Article, did not cease to advance and



to extend even the abuse and labored work, it was not the same in military structures; the architects returned to the simplest arrangements, and the more homogeneous system of construction. At each step we are then obliged to stop in the study of the art of building by the artists of the middle ages, and to resume a new path; for this logical art lends itself to all conditions, to all needs that appear, without ever attempting to impose a routine. At the moment when religious edifices excluded the round arch, and the art of construction abandoned itself to excessive research in churches, in military structures it finally returned to forms more serene, to the system of concrete and passive construction, so well developed by the Romans. In the fortifications of the city of Carcassonne built at the end of the 12 th and the beginning of the 13 th centuries, we have a striking example of this revolution.

As we have had occasion to present in this Dictionary a great part of the principal works and details of those fortifications,<sup>1</sup> we shall here limit ourselves to giving in its entirety and details one of the most important defenses of this enclosure, to show our readers what the art of military construction became under Philip the Bold. We shall select the principal tower of that enclosure, the tower called du Tresau, which yields in nothing to the finest antique structures that we know. This tower defends one of the projections of the inner enclosure. It is constructed according to the system explained in our Fig. 142 (G), i.e., its two stories above the ground outside consist, on the side of attack, of niches between the internal buttresses, recesses at the bottoms of which are pierced slots that command the exterior. From one story to another, these niches alternate like those of the tower of the castle of Coucy. The ground in the city is 23.0 ft. above the external soil. Fig. 149 gives the plan of the tower du Tresau at the level of the ground story (cellar next the city), on a level with the external soil. Beneath that story exists a cellar cut in the rock, lined with masonry and vaulted, to which one descends by the screw stairs placed in the angle at the right of the tower. The second story (150) is raised several steps above the ground in the city. This ground story and the second story (ground story next the city) are vaulted by means of transverse, side and diagonal arches, all by the Go-



Gothic method. The second story (Fig. 150) has a fireplace G, a door opening on the tower of the city, a closet E for the chief of the post and privies F corbelled out. The third story (second next the city) (151) has solid external walls in order to strongly load and connect together the lower construction, whose circular wall is pierced by alternated niches and slots; that story is covered by a floor. The fourth story (152) presents a defensive gallery A open to the sky, at the centre being a hall beneath the roof, lighted by two windows opened in the gable wall D. Besides the stairs B that ascend from the bottom, there is found at the end of the defensive gallery a second stairs B'; both ascend to the summit of two watch towers, that flank the gate D. Placing the back against the gable wall on the floor of the ground story (plan, Fig. 149), and looking toward the side for defense, we see (153) the internal constructions of this tower. We assume the vault separating the ground and second stories to be demolished, in order to understand the arrangement of the internal niches, forming slots, alternating solids over voids to cover all points of the external circumference, thus cutting the piers and avoiding vertical ruptures, according to the system adopted for the towers of Coucy, explained above. The simplicity of this construction, its solidity, the care with which its surfaces are jointed with fine cut stones internally and externally, indicating fully the attention that the architects of the end of the 13th century gave to the execution of these structures, how they sacrificed everything to the needs of the defense, and how they knew how to subject their methods to the different sorts of construction.

In passing around the fortifications built about the city of Carcassonne under Philip the Bold, one would scarcely suppose that a few years later was erected in the same city the choir of the church of S. Nazaire, several parts of which have been presented to our readers.

The tower du Tresau is covered by a steep roof forming a conical hip on the side next the country, and that on the side toward the city adjoins the gable pierced by windows lighting the different stories. If we make a transverse section of the tower looking toward the gable, we shall obtain Fig. 154. Examining the plans, one sees that this gable wall is n



not very thick, compared with its height. But at this side it is only necessary to close the gorge of the tower, and besides this tower is stably maintained in the vertical plane by the two watch towers F F, that by their foundations and weight present two points of support with great stability. The junction of the covering and the gable is well sheltered by those steps forming spaces on the internal surface, and that facilitate an oversight of the upper parts of the tower. The roof (whose slope is indicated by the dotted line I K) rests on the two large eave walls K, entirely separating the defensive gallery from the interior of the central hall. At the level of the rampart, the defensive gallery G surrounds the structure at the side next the city, as that of the outside is at A B.

Besides, the care devoted to the general conceptions of these two military edifices is manifested in even the least details. One finds everywhere the evidence of reflecting observation and of consummate experience. Thus without enlarging too much on the details that find their places in the Articles of the Dictionary, we shall limit ourselves to pointing out one of the internal arrangements of the structure of the fortifications of Carcassonne at the end of the 13<sup>th</sup> century. Some of these towers most exposed to the efforts of the assailants, at their fronts are finished with projecting angles designed to keep the pioneers away and to offer a powerful resistance to the blows of the battering ram. (Arts. Architecture Militaire; Tour). Now in this particular case, how is the jointing of the courses arranged (155). The joints of the stones in the front part of the tower are not drawn normal to the curve, but at 15° degrees from the axis A B; thus the effect of the ram on the projecting angle, the narrowest part (consequently most easily attacked) is neutralized by the direction of those joints, that transfers the blow to the points joining the tower with the adjacent curtains. If the besieger undermines, after excavating beneath the angle and even beyond it, he finds joints in the stone not leading toward the centre of the tower, compelling long and difficult labor, for it is necessary for him to remove with crowbar each block, that is obliquely presented, and he cannot disjoint them as easily as if they were cut in wedge shape. In our Fig. we have traced the jointing of two courses by full and by dotted lines.



While the religious and civil architecture adopts superfluous ornaments, so that the construction becomes more labored during the 14 th and 15 th centuries, military construction on the contrary daily employs the safest methods, the simplest means and procedures with the greatest resistance. The military structures of the end of the 14 th and beginning of the 15 th centuries everywhere adopted the round and segmental arches; the jointing is done with particular care; the concrete masonry is excellent and well treated, which is rare in religious structures. All causes of useless expense are avoided. Thus for example, the arches of vaults, that in the 13 th and even the 14 th centuries sprung from corbels, penetrate the surfaces as indicated in Fig. 156.<sup>1</sup> The springing of the pointed arch is cut in the facing courses of the tower. There are no side arches; this member justly seems superfluous. The first voussoir A of the filling of the vaults itself belongs to the facing; a simple recess cut in the facing receives the other stones forming the triangles between the arches. At the same time that all the details of the construction become simpler, and less expensive in execution, the jointing is perfected, the materials are better chosen for the places they occupy; the surfaces are dressed with extreme care even in the foundations, for it is necessary to leave opportunity nowhere for the work of the miner. If built on the rock, that is leveled with all the perfection given to the beds of coursed stone; if there are roughnesses and cavities in the rock, these are filled by good courses. One recognizes at all points this oversight and attention, that scrupulosity, which are for the builders the most evident sign of a very perfect art and method followed.

Note 1.p.278. From the towers of the castle of Pierrefonds, beginning of 15 th century.

Artillery came to arrest the architects at the moment when they had carried as far as possible the study and practice of military construction. Before it these refinements of defense became useless; it was necessary to oppose to this new means of destruction enormous masses of masonry or embankments. Cannon, by overthrowing those covered parapets and those well arranged machicolations, dismantling the ramparts and undermining their bases, no longer permitted the use of these ingen-



ingenious combinations made to resist near attacks. Yet such was the strength of many strong places in the 14<sup>th</sup> and 15<sup>th</sup> centuries, that regular sieges were often necessary to breach and reduce them. In order not to extend farther this Article, already very long, we refer our readers for the study of the details of fortification in the middle ages to Arts. Architecture Militaire, Boulevard, Chateau, Courtine, Creneau, Donjon, Echauguette, Machicoulis, Porte, Siege, Tour.

#### CONTRE-COURBE. Ogee. Reverse Curve.

This name is given today to the reversed curves that terminate a pointed arch at its top. Ogee curves form the upper part of a recurved arch. (Art. Accolade). During the 14<sup>th</sup> century appear ogee curves at the top of acute arches. At first they have little importance, then they gradually develop and become one of the richest motives of Gothic architecture in its decline. These ogee curves are already seen to surmount the archivolts of the windows lighting the chapels at the North of the cathedral of Amiens, and those chapels date from 1375.

Let us see how these recurves are traced; as a general rule reverse curves assume much less importance as the arches are curved at A and B; this is the perfect equilateral arch; in this case the reverse curve rarely starts except at one fifth the curve at D. Drawing the line from P to D and extending it to intersect the axis O X of the arch, then the second line A D also prolonged, a perpendicular is erected at the middle of the line D E. The intersection of this perpendicular with the line A D prolonged gives the point F, the centre of one reverse curve, that then touches at the point E. If the arch be less pointed and its centres are placed at points G, which divide the base of this arch into three parts, each curve will be divided in four parts, and the beginning of the reverse curve will be at H. Proceed as before by drawing a line E H prolonged; to intersect the axis O X, then a second line G H prolonged; erect a perpendicular at the middle of the line H K, and the intersection of this perpendicular with the line G H prolonged will give at L the centre of the reverse curve. If the arch be round or segmental, as frequently occurs at the beginning of the 16<sup>th</sup> century (sketch P), the reverse curve will start at R, half the quadrant S T, and employing



the same method, one will obtain that reverse curve R V. The profile of the archivolt being U U', the operation must be made at the edge Z of the projecting member of this archivolt; one will thus obtain the trace Y, so that the different members a of the mouldings may have their reverse curve intersecting the master curve. As for the space B, it is usually not cut deeper than the face d of the wall, and it is decorated by ornaments, reliefs, or remains flat; the projecting member alone of the archivolt forms the reverse curve. In the 16<sup>th</sup> century are frequently found archivolts with broken reverse curves as indicated in sketch Q, the radii g h, i R being equal. These are abuses of Gothic art, which have been justly rejected by the architects of the Renaissance, and it must be stated, that nearly always by these abuses do men wish to judge that art, which certainly could avoid labored works, so much the less motivated, because they oppose the jointing and trouble the constructor. But the architects of the last epoch of Gothic architecture were gradually led to surmount the broken arches of this useless member by the increasing predominance of the vertical line over the horizontal line. The broken arches themselves seem to oppose by their curve terminated at top the ascending lines of the edifice; it was necessary for these arches to reach the vertical line, like all parts of the architecture. One is always disposed to indulgence for artists, who although in a false path, atone for the vice of the principle by perfect execution and a certain taste in details. This is what occurs when one examines our edifices of the end of the 15<sup>th</sup> century. Without approving the abuses into which they fell, the labor in the combination of forms, one is often seduced by the charm that they knew how to display in the infinite details of these combinations. The artists of Ile-de-France were the only ones, who at that epoch of decadence were marked by refined taste, even in their errors. And to mention here only the reverse curves surmounting archivolts, we see in that privileged province them give to that singular innovation in forms relative proportions, that one cannot find elsewhere. They avoid applying reverse curves to great archivolts, which always has a heavy and ungraceful effect; they trace them only above secondary arches, and frequently disguise their sharpness by rectifying a little the cu-

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curve produced by the compasses. It will suffice us to give an example to emphasize this observation. In the court of the charming mansion de la Tremouille, that we saw demolished in 1841 (not without regret for that destruction was an act of useless vandalism, and which it would have been easy to avoid), there existed a turret whose projecting portion was borne by two columns.<sup>1</sup> An archivolt surmounted these two points of support, and this was cut in a reverse curve. (See Fig. 2, opposite). One sees that the architect traced the reverse curves, not merely by two lines with the compasses, but rectifying the sharpness, as we have just said. This archivolt has only about 3.3 ft. opening, and is not cut in voussours; its upper part is taken in a single course resting on two imposts. Thus this is merely a decoration, and the reverse curves skilfully connect the apex of the arch with the numerous vertical members by which the turret is finished from top to bottom. It is the same with this example as with every work of art; everyone can know the rule, but it is only artists of taste, who know how to apply it properly. In the numerous monuments of the 15th century that cover France and Germany, reverse curves are rarely drawn with sufficient refinement; their beginnings are placed too low or too high, crushing the lower arch or do not join its branches. Let us add that reverse curves never produce a good effect, when they surround arches of small diameter.

Note 1.p.283. Some fragments of this mansion are now deposited in the front court of the Ecole des Beaux Arts.

#### CONTREFICHE. Brace. Strut.

An inclined member of carpentry, whose function is to serve as a shore in carpentry. The member A (1) is a brace. (Art. Charpente).

#### CONTRE-FORT. Buttress.

This is a reinforcement of the masonry built at a load or thrust. It is unnecessary to explain here the function of the buttress, for that function is fully developed in Art. Construction. We shall restrict ourselves to mentioning the different visible forms given to buttresses in religious and civil edifices, and the transformations, that this architectural member suffered from the 10th to the 16th centuries.



The Romans having adopted the cross vault in their edifices must necessarily seek means to resist the effect of the thrust of these vaults. They found these resistant masses in the combination of the plan of the edifices, which one can recognize in visiting the halls of the baths, and particularly the edifice known at Rome under the name of the basilica of Constantine. But when the barbarians took possession of the last traditions of the art of construction left by the Romans, they found no artists sufficiently learned or enlightened to understand what was wise and reasoned in the plans of the vaulted edifices of Roman antiquity; seeking to imitate the plans of the Latin basilicas, desiring at first to vault the side aisles, they were necessarily forced to resist externally the thrust of these vaults by reinforcements of masonry, to which they first gave the appearance of engaged columns or of half cylinders, then soon that of square piers extending up to the cornices.

Among the oldest buttresses of the middle ages may be cited those supporting the walls of church S. Remy of Rheims (10 th century). These are half cylinders (1), stiffening the walls of the side aisles at the points of the thrusts of the vaults, and the walls of the central nave at the trusses of carpentry; for then that created a nave that was not vaulted. These primitive buttresses are only crowned by cones or by capitals, that often support nothing. The cylindrical form <sup>was</sup> abandoned in the North for buttresses, while that form persisted in the West till the middle of the 12 th century. Still may be seen in Beauvoisis a number of churches or monastic edifices, that adopted the rectangular form for buttresses, very broad at the base and quite narrow at the top, so as to not exceed the projection of the cornice. We give here an example of them taken from a little church of Allone, whose chevet appears to have been erected about the end of the 11 th century. (2).

These buttresses resisted thrusts of the cross vaults, and they are composed so as to be able to form a square return, as indicated by the plan A. Their top, which is no more than a pilaster with about 8 ins. projection, is terminated by a sculptured ornament B, slightly representing a capital on which rests the slab serving as a cornice. Yet the primitive rectangular buttress with small projection is generally crowned a

and has a base, as indicated by fig. 3. in fig.



and have bases, as indicated by Fig. 3, in Ile-de-France, Champagne, Burgundy and Normandy; but in the last province from the 11 th century, they are frequently composed of two or three parts distinguishing that section, while in elevation they rise from the base without side projections; such are the buttresses that flank the facade of the abbey church of S. Etienne at Caen (4). Besides, contrary to the Burgundian method and that of Champagne, these old Norman buttresses in monumental construction are erected in low regular courses of the same height as those forming the facings of walls, and are perfectly connected with them. But in structures built with economy and only having walls of plastered rubble, the Norman buttresses are composed of unequal courses and often of slabs set on edge. Then sometimes the windows lighting interiors are opened, even on the axes of the buttresses; that is one means of avoiding the furnishing of cut stone required to form the jambs and archivolts of those windows, if they were pierced between the buttresses. It is understood that these openings made in the middle of the piers can only belong to edifices not vaulted but covered by carpentry ceilings.

We know several examples of this singular arrangement, one in the Church of S. Laurent near Falacis (5), the other in that of Montgaroult (6), a third at Ecageul near Mezidon.<sup>1</sup>

Note 1.p.287. These two drawings were furnished to us by M. Ruprich Robert, to whom we owe an excellent restoration of the church of the Trinity at Caen.

We further give in Art. Construction the procedures of jointing employed during the Romanesque epoch for flying buttresses and jointing them to the walls. We shall then only have to occupy ourselves here with the forms given to these points of support during the middle ages.

One will readily admit that the edifices, being very simple externally before the 12 th century, the buttresses must share in this simplicity, and that they must present very slight projections, since the walls themselves were very thick. Indeed they were then merely a vertical projecting series of stone quoins, reinforcing the principal points of support, and they were terminated at top in the manner indicated in the preceding Figs., or they were covered by the slab of the cornice as in the sketch (7), not projecting beyond it. But when in the

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12 th century the system of construction employed until then was modified by the lay school, so that this school, leaving Roman traditions aside, could apply systematically the principles of Gothic construction, the buttresses became the principal members of every vaulted edifice. The walls were no more than intended to enclose the naves, and sort of screens, adding nothing or little to the stability. Then on the exterior the buttresses themselves alone constituting the edifice covered by the masonry vaults, it was necessary to cause their function to oppose frankly, to give them the forms in accordance with this function, and to decorate them as much as any architectural member could be, that not only must be stable, but still retain the appearance of strength. Yet only by transitions the first Gothic architects arrived at giving their buttresses the importance, that should be taken by structures of this kind. Their first attempts were timid; the traditions of Romanesque architecture had overthrown the remnant of influence, from which they could not withdraw abruptly. It is clear that while desiring to adopt in the interior their new system of buttresses, they sought to retain on the exteriors of edifices the Romanesque appearance to which their eyes were accustomed, or that if by force the buttresses must present a very considerable projection from the face of the walls, they endeavored to recall in the mode of decorating them architectural forms, that rather belong to piers supporting a vertical load than to abutting piers. These attempts are evident in Beauvoisis, fruitful in vaulted edifices of that epoch of transition. We give two examples of these to our readers. The buttress (8) strengthens the wall of the side aisles of the nave of church of S. Etienne of Beauvais (12 th century); like all the masonry of the edifice, it is constructed of small materials, and the little upper columns appearing to support the cornice are built in courses bonded with the structure. The buttresses (9), projecting more than those of church S. Etienne, belong to the old collegiate church of S. Evremont at Creil (12 th century). It is here evident that the architect had no other idea for decorating this abutting pier, than to give it the appearance of a pilaster ornamented by capitals. Not knowing too well how to terminate this pier, he covered it by a stone slope decorated by scales imitating tiles. The system or nra-



ornamenting buttresses by little engaged columns at the angles, and intended to disguise the dryness, during the 12 th and 13 th centuries, belongs almost exclusively to the basins of the Oise and Aisne. But still one perceives that the architects of that province in the 12 th century, already very skilful in the construction of vaults, were very much embarrassed to know how to harmonize the successive recessions, that must be given to the abutting piers for resisting the oblique thrusts of vaults with the appearance of vertical support retained for these piers. One recognizes the traces of these uncertainties in the angle buttresses of the south tower of church of S. Leu d'Esserent, a buttress of which we give the superposed members (10).

With regard to these angle buttresses, it is here necessary to remark, that there is presented a difficulty to which the architects of the 12 th century did not give the most natural solution at first. If these buttresses abutted a tower, for example, whose walls because of their height must recede at each story as indicated by Fig. 11, they did not know how to connect the tops of these buttresses with the point B, the angle of the upper story of the tower; it was necessary for them to build the sides E F of these buttresses vertically and to recess the sides G H to reach the point B, which produced a bad effect, the buttresses appearing to rise diagonally as shown by Fig. 10. To avoid that defect, the means was very simple; so after several experiments it was employed; this was (11 bis) to erect the buttresses in the internal and external surfaces of the upper story A B C, and to allow the projection in the angle K of the offsets of the lower stories of the walls. Henceforth this method was invariably followed by Gothic constructors.

On the walls of the church S. Martin of Laon, cited above, and whose erection dates from the middle of the 12 th century, one already sees buttresses designed with art and bonded well to the structure. The gable wall of the south transept of that church possesses angle buttresses, that skilfully recede, and a buttress placed on the axis beneath the rose window, so as to properly abut the wall. (Art. Pignon). The band beneath the lower windows is carried around these buttresses, and serves as a first course of the slope of their second recession.



Above this are the abacuses of the capitals of these same windows, that begin the third recession, wider on the face than at the sides, so as not to diminish too abruptly the width of these piers. The central abutment alone receives a third band connected with the archivolts of the second windows, while the angle buttresses stop with a simple slope beneath this band. With this freedom, that is one of the qualities of the architecture of the 12<sup>th</sup> century at the moment when it left Romanesque traditions, the constructors of the church of S. Martin of Laon, having had the idea of placing in the transepts their square eastern chapels, and desiring to vault these transepts by two cross vaults only, must erect a buttress on the axis of the middle chapel. See how they proceeded to solve this problem; on the walls separating these chapels they built two buttresses A A (12), connected by an equilateral pointed arch; then on the crown of that arch they built the buttress B designed to abut the transverse arch, and the diagonal arches of the high vault. This arrangement permitted them to pierce a window under the buttress B, in order to light the transept over the entrance archivolt of the middle chapel. We still see on the exterior of the apse of the monastic church of S. Leu d'Esserent, a central chapel in two stories, whose upper buttresses rest on the archivolts of the lower windows. The weight of these buttresses is distributed over the jambs and piers separating these windows. In the 13<sup>th</sup> century the architects renounced this alternation of solids and voids, and the buttresses rest on the ground; yet there was not that mode of building and precious resources, in that it permitted the unequal division of the different stories of an edifice, which in many cases was required by the internal arrangement. Until the end of the 12<sup>th</sup> century, men had not yet thought of increasing the stability of buttresses by means of an upper loading; but sought to make them stable by their mass and the area of their horizontal section. Yet we already see in the preceding example (Fig. 12), that the head of the buttress extends above the cornice of the edifice, and that it is loaded by a pinnacle.<sup>1</sup> But when these constructors diminished the areas occupied by the points of support, they supplemented the weak horizontal section of these points of support by upper loads.



Note 1.p.2933. The actual pinnacle must have been rebuilt in the 14 th century, but it is evident that one existed in the 12 th century.

Before making known the successive advances of <sup>the</sup> construction of the buttresses during the 13 th century, we must mention certain varieties of that important member of architecture in the principal provinces. In Ile-de-Franc, Champagne and Normandy, the buttresses generally take the rectangular form, and they have from the Romanesque epoch the appearance proper for them, that of an abutting pier, a resistant mass. But in the provinces where Gallo-Roman traditions were retained until the end of the 12 th century, as in Burgundy, Auvergne, Poitou, Saintonge, and Languedoc, the architects sought to give their buttresses the appearance of a Roman order, i.e., they composed them of one or more engaged columns surmounted by their capitals and bearing the entablature, reduced to a simple moulded slab.

We see on the exterior of the apsidal chapels of the churches of Auvergne, a part of Guyenne, of Languedoc and of Poitou, buttresses composed after this system. (Art. Chapelle, Figs. 27, 33). In Burgundy, these buttresses frequently terminate with a slope set on the capital, as shown in Fig. 13.<sup>1</sup> Even sometimes the buttresses of the 12 th century on the upper Marne and along the Saone affect for their front face the form of Roman fluted pilasters imitated from the Corinthian order, as around the apse of the cathedral of Langres. The buttresses of the apsidal chapels of Notre Dame of Chalons-sur-Marne are only engaged fluted columns, whose capitals bear statuettes covered by canopies joined with the cornice. These traditions were entirely rejected by the artists of the 13 th century. In the architecture of that epoch, and when Gothic art is frankly adopted, the buttress is a buttress and no longer attempts to conceal itself under a form borrowed from antique architecture. We have a remarkable example of the primitive Gothic buttress on the apse of the church of Vertheuil near Mantes. We give (15) the elevation of these buttresses, and their plan (15) at the height of the external passage that extends beneath the sills of the windows entirely around the chevet. It is not doubtful that here the architect desired to oppose to the curve of pressures produced by the arches of t



the vault an oblique abutment, resistant by its mass and by the section of its profile, composed of a succession of recessions, but that they had not yet thought of neutralizing the oblique thrust by an extra vertical load. They soon perceived that these repeated slopes were worn by rainwater falling in a cascade from one to the other; that it was not necessary to give the buttresses so great a depth, since the resultant of the thrusts acted only at their axes, and that it sufficed to ensure their stability by a depth proportioned to their height, considering them as portions of the walls. The buttresses of the apsidal chapels of the cathedral of Mans built about 1220, while retaining the principle adopted at Vetheuil, already present a sensible improvement. These buttresses (16) recede above each slope, and then are crowned by gargoyles that cast water from the roof far outside the upper recessions. It must be stated, that these chapels were built on the slope of a precipice, and that it was necessary to give the buttresses a considerable base to maintain the structure, whose internal pavement is elevated about 16.4 ft. above the external soil. About the middle of the 13th century, the architects definitely rejected the slope; they raised their buttresses vertically at the sides, except a slope at the base, having recessions of an inch or so on their outer face above each bond or drip that protected the surfaces of these faces at different heights. Thus are constructed the buttresses of S. Chapelle of the Palace at Paris, and those of the apsidal chapels of the cathedral of Amiens. (Art. Chapelle, Figs. 3, 40). The buttresses thus retaining at their tops a projection nearly equal to that of their plan at the level of the ground, men had the idea of crowning them by a cornice that served as a gutter, and of placing gargoyles at the projecting angles of this cornice or the middle of each drip moulding, which in that position casts the rainwater far from the surfaces. Above the cornice were raised pinnacles, that by their weight increased the stability of the buttresses. The construction gradually becomes lighter at the end of the 13th century, the architects constantly seeking means of diminishing the volume of materials while preserving the stability of their structure by vertical loads, then often built these buttresses only to the point of thrust of the vaults, and on these



engaged piers they placed pinnacles detached from the construction having no effect other than to load the abutting portion of the piers. One finds one of the best examples of this sort of construction around the apsidal chapels of the cathedral of Seez. (End of 13<sup>th</sup> century). (17). The thrust of the vaults does not act above the level A. There the buttress ends in a gablet, and ceases to be connected to the angle of the chapel; astride the gablet rises a detached pinnacle B, only connected to the structure by the gargoyle that crosses it and by the block C that serves as a balustrade. Thus the pinnacle loads the buttresses, serves as support of the gargoyle, maintains the projecting angle of the balustrade, has not the heavy appearance of a buttress rising at once to the cornice, and serves as a transition between the lower massive parts and the lightness of the crowning parts, by giving strength to the projecting angles of the chapels.

Note 1.p.295. Of the obedience of S. Jean-les-Bons-Hommes near Avallon. (Architecture Monastique, Fig. 12; 12<sup>th</sup> century). Here the slope that terminates the capital is cut in a single stone.

About the middle of the 13<sup>th</sup> century in religious edifices and vaulted halls, the architects had adopted the method of entirely suppressing the walls, and of opening under the side arches of the vaults, windows that occupied the internal surfaces left between two buttresses. (Arts. Architecture Religious; Construction). This arrangement produced by the system of construction that tended more to transfer the load to the buttresses, gave a very rich appearance to the exterior of the edifices by accompanying with tracery windows in all spaces left free, but emphasized the more the nakedness of the external piers, which it was essential to give great solidity. The architects were then led to decorate also the buttresses so as not to present an offensive contrast between the lightness of the windows and the heaviness of the piers. Thus at the beginning of the 13<sup>th</sup> century we already see the buttresses of the cathedral of Chartres decorated by niches with statues. This ornamentation was at first timid, enclosed within the outline of the structure, but developed rapidly; it was combined with the upper pinnacles as around the nave of the cathedral of Rheims (Art. Pinnacle), also as on the western facade


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of the great hall of the synod of Sens (Art. Salle) about 1240. Yet until the 15 th century the buttresses retained the appearance of strength and stability that is proper for them; during the 14 th century itself, it seems that the architects ceased to decorate their fronts; they contented themselves with surmounting them by very high and very rich pinnacles, as around the chapels of the cathedral of Paris. But let us not forget that the 14 th century, which frequently falls into excess of lightness, is generally sober in sculpture. Among the most richly ornamented buttresses of the end of the 13 th century and beginning of the 14 th may be cited here those of the choir of S. Urban of Troyes. The decoration of these buttresses always consists only of a facing of stones set on edge, superposed and fixed by cramps to the piers built of courses. (Art. Construction, Fig. 103). This system of ornamental facings, much used in the 13 th century, was entirely abandoned by the architects, who were first skilful builders, and left but a small space for the imagination of the artist.

About the end of the 14 th century, they commenced to modify the facings of the buttresses, which until then had retained their surfaces parallel and perpendicular to the face of the wall; they sought to disguise the rigidity of their angles, to diminish the obscurity produced by their strong projections, by setting their courses diagonally as indicated in Fig. 18. By means of the cut-off angles A B were obtained more space; the windows placed between them were less masked and received more light from outside. The two intersecting squares with edge in front permitted a superposition of pyramids with a very happy effect. These exist very pretty buttresses built on this system along the chapels of the nave of the cathedral of Evreux. (19). The Gothic epoch in its decline only loaded with details these essential members of the architecture, to the point of removing their character of strengthening piers. Their horizontal sections only present strange complications of curves and of squares intersecting, leaving niches for statuettes and forming corbels to support them; all that was drawn and cut with science and extraordinary perfection, but presenting to the eyes only confusion, after so many efforts and difficulties in execution. Whoever desires to consider, for example, the great buttresses that strengthen the western



facade of the cathedral of Rouen, and that were built at the beginning of the 16<sup>th</sup> century under cardinal of Amboise, can pass an entire month in drawing their plans, in understanding the intersections of the hundreds of prisms that compose them; yet this labor and research only produce a disagreeable effect in execution.

The buttresses of the 15<sup>th</sup> century and beginning of the 16<sup>th</sup> are generally composed of a body with two faces intersecting at angles of 45° degrees. Thus the base is square, presenting one face parallel and two perpendicular to this wall.  Above the first offset the square presents an angle instead of one of its sides in front; the two diagonal sides are then flanked up to a certain height by two additions with square bases, the sides parallel to the original sides and forming prisms terminated by pyramids; above the buttresses present an angle that bears gables, then its pinnacle. The plan (20) gives the horizontal section of this sort of buttresses, and the elevation (21) their appearance. This pinnacle is applied with distressing monotony during the last times of Gothic architecture. Sometimes these squares have their sides set parallel or diagonal to the surfaces, are again subdivided and hollowed out in niches, covered by a more or less great number of mouldings; but the principle is always the same. (Arts. Pinnacle, Trait). Again in Ile-de-France the abuse of these intersections is less frequent, and until the last efforts of Gothic one meets with refined taste; that is felt among the architects a sort of repulsion for exaggerations.

The pretty mansion de la Tremoille at Paris, whose demolition is to be regretted forever, and that was built in the first years of the 16<sup>th</sup> century, in the midst of the luxury of the architecture of that epoch, retained that sobriety in the details and that reason in the composition without which every architectural work wearies the eyes. A vaulted portico open to the court, extended along the building next the street. These vaults rested on slender piers strengthened by projecting ribs taking the places of buttresses, and giving area to those piers.<sup>1</sup> The archivolts of the porticos penetrated the oblique sides of the buttresses, so as to connect the courses with the vertical points of support. At the mansion de la Tremoille are not found those loads by canopies, corbels, int-



intersections of prisms, that give an edifice the appearance of goldsmith's work made to be minutely examined near by. The construction of that habitation was so well understood, that in spite of the extreme lightness of the piers and the thrust of the vaults, nothing had moved; still when the demolition occurred no iron ties were found at the level of the second story. It is unnecessary to state, that at the level of the imposts of the arches of the vaults had not been placed, as in the porticos of Italian architecture, those horizontal bars of iron, that so brutally emphasize the weakness of the constructors.

Note 1.p.304. see Arch. civ. et dom. of MM. Verdier and Cotte. Plate 2.

The Renaissance evidently found itself greatly embarrassed, when necessity compelled it to place buttresses on the exteriors of edifices to resist thrusts. It imagined nothing better than to decorate them by pilasters or columns borrowed from Roman art. Sometimes, as in the court of the old chateau of S. Germain-en-Laye, it connected them at the different stories of the structure by arches forming a gallery or balconies; but that was again a Gothic tradition, whose origin we shall indicate in our Art. Construction, Fig. 120. It did not fail to disappear like the others, and when it was absolutely necessary to establish buttresses before the facades of religious or civil buildings, they superposed Roman orders over each other. If this singular application of the antique orders produced a grand effect (which we refrain from deciding, since this is a matter of taste), it had as result the disguising of the true function of the buttress; as construction that of causing useless expense and of placing several cornices above each other; now these repeated cornices have the inconvenience of stopping rainwater and causing dampness to enter the masonry. But let us not forget that the important matter for architects from the end of the 16th century, was to seek pretexts for placing columns, no matter how. Everyone desired to have erected one or several orders, and everybody found them very beautiful. From the instant that in architecture one abandons rules imposed by good sense and reason, we confess that to us it matters very little whether the forms adopted are borrowed from Roman or Gothic. They ended by regarding the buttress as a



confession of weakness, and by suppressing it in modern structures, but as it is necessary that masonry should stand upright, that thrusts should be abutted, and that the overthrow or buckling of the walls should be arrested in vast buildings, men have adopted the system of giving the walls the thickness, that should only be given to some isolated piers, in brief to buttresses. Masonry being estimated by volume and work, thus they pay very dear for the pleasure of saying and repeating that the Gothic constructors were barbarous; and what is pleasant is to hear said very seriously to those paying for those great useless walls, that buttresses indicate the ignorance of the constructors.

#### COQ. Cock. Weathercock.

William Durand,<sup>1</sup> in his *Rational des divin offices*, expresses himself thus with regard to the weathercock surmounting the highest point of the church in the West.

Note 1.p.305. *Rational*. Vol. 1.chap.1. sect. 22.

"The weathercock placed on the church is the image of the preachers, for the cock wakes in the dark night, marks the hours by his song, arouses those that sleep, and celebrates the appearing day; but at first he wakes and excites himself to sing by beating his sides with his wings. All these things are not without a mystery; for the night is this age; those that sleep are the sons of this night, resting in their iniquities; the cock represents the preachers that preach with a loud voice and awake those that sleep, that they may reject the works of darkness, and they cry: 'Woe to those that slumber! Arise thou that sleepest!' They announce the light to come, when they preach the day of judgment and the future glory; but filled with prudence, before preaching to others of the virtues, they arouse themselves from the sleep of sin and chastize their own bodies. The apostle himself is a witness of this, when he says; 'I chastize my body and reduce it to servitude, fearing that by chance after having preached to others, I may myself come to be reprov'd.' And like the weathercock, the preachers turn against the wind, when they strongly resist those that revolt against God, by rebuking them and convincing them of their crimes, from the fear that they may be accused of having fled at the approach of the wolf. The i



iron rod on which the weathercock is fixed represents the inflexible word of the preacher, and shows that he should not speak of the spirit of man but of that of God, according to this word; 'If one speaks, that this is the speech of God.' And because this rod itself is placed above the cross or the ridge of the church, that signifies that the scriptures are completed and confirmed."

Thus in the 13 th century it was well understood that the cock placed at the summit of towers was a symbol; further it is clear that this cock was moveable and served as a weathercock. But before that epoch there is a question of cocks placed on the spires of churches. The Bayeux tapestry, that at least dates from the beginning of the 12 th century, shows us a cock on the abbey church of Westminster, and contrary to modern customs, that cock has its wings spread.<sup>1</sup>

Note 1.p.306. We refer our readers to the learned dissertation of M. Barraud on those cocks of churches. (Bull. mon. Vol. 16. p. 277.

Walston, a 10 th century author, in the book of the life of S. Swithin, speaks in a very poetic manner of the cock placed at the apex of the church that bishop Elfege had built at Winchester.<sup>2</sup>

Note 2.p.306. We borrow this translation from the review of M. Barraud.

"A cock of elegant form and all resplendent in the gleam of gold, occupies the summit of the tower; he looks on the earth from on high, he dominates all the country. Before him are presented the shining stars of the North and the numerous constellations of the zodiac. Beneath his proud feet he holds the sceptre of command, and he sees below him all the people of Winchester. Other cocks are humble subjects of him, that they see thus floating in the midst of the air, and commanding with pride all the West; he faces the winds that bring rain, and rotating himself he boldly presents his head. The terrible efforts of the tempest do not disturb him, he receives with courage both the sniw and the force of the hurricane' he alone sees the sun at the end of its course and sinking into the ocean, and it is given to him to salute the first rays of aurora. The traveler that perceives him afar fixes his eyes on him; without thinking of the distance still to be passed, he advan-



advances with new ardor. Although the may really be very far from the end, his eyes persuade him that he is near it."

This symbol of vigilance, of struggle against the force of the wind, placed at the highest point of religious edifices, belongs to the West. There is no question of cocks placed on the towers of the churches of southern Italy. Would it be for this that they have been removed from most of our churches? Or at least that they have not generally been replaced, when these have rusted?

We have found no cocks on towers of an old epoch, or those that we have seen were of rude design and work, that we do not believe it necessary to reproduce them here. We can only desire cocks to resume their old places; were it on as weathervanes, they have their utility.

#### CORBEAU. Corbel. Bracket. Consol.

A support of stone or wood projecting from the face of the wall, having its front moulded or carved, presenting two plain sides, and receiving either a cornice slab, a band, the impost of the vault, a corbelled pier, the lintel of the doorway, or the main beam, etc. The actual origin of the corbel is given by the projection of a wooden beam beyond the face of a wall, as indicated by Fig. 1, a projection arranged to support corbelled half timber work, a roof, post, etc.

During the late empire, the Romans had adopted corbels of stone or marble to support small orders of architecture projecting from the walls, crownings of openings, piers, or even cornice slabs and bands. The architects of the Romanesque epoch adopted this member and were satisfied to employ it as an ornamental detail, but they used it so well that it became one of the most common means of construction during the 11th and 12th centuries. In their turn the architects of the Gothic epoch employed it in a great number of cases with success. No wooden construction was long accepted by the barbarian masters of Gaul, and when they could erect edifices of masonry, they retained for certain architectural forms the forms given by carpentry; only they imitated those forms in stone. The oldest corbels always took the form of the end of a beam or joist, ornamented by mouldings or sculpture; such are the corbels that one sees in the nave of the church of S. Menoux near Moul-



Moulins (9 th or 10 th century), and that support a slab originally receiving a ceiling of carpentry. (2). Below this cornice, between the archivolts of the side aisles the verticals of the columns are also seen corbels carved in the form of human heads (3), which were probably intended to receive the feet of anchors relieving the tiebeams of the carpentry. The statuaries of the 10 th, 11 th and 12 th centuries appear to have taken the stone corbels as one of the motives most suitable for sculpture. They decorated them by figures of men and of criminals, heads, symbolical subjects, such as the vices and virtues, the signs of the zodiac, the labors of the year; they strove to vary them. Particularly in Auvergne, Berry, Poitou, Bourbonnais and along the Garonne, one finds on the edifices of the romanesque epoch a prodigious number of corbels of remarkable execution, dating from the end of the 11 th century. These corbels are nearly always intended to support cornice slabs or bands.

Although vaults were very early adopted in the edifices of Auvergne, yet the tradition of coverings in carpentry made itself felt by the presence of corbels, that were retained under cornice slabs until the end of the 12 th century. The church of Notre Dame du Port at Clermont, that of S. Etienne of Nevers, possess cornices with ornamental corbels very interesting to observe. Most assume the form given by Fig. 4. This is evidently an imitation of the end of a dressed beam. These volutes accompany the principal rib and are nothing more than the shavings produced by the hand of the carpenter to clear the rib at the middle. It suffices to know how the work with the adze can cut away the end of the beam and reserve there a bracket, to recognize that these volutes represent the shavings produced by the work of the carpenter. A figure (5) will make our explanation intelligible to all. Take a beam at the end of which is to be arranged a bracket A. The workman will remove with his adze a series of thin chips so as not to split his timber; then he will cut off those at their base, if he desires to entirely clear the bracket. Seeing that these chips form an ornament, he had the primitive idea to not cut them off, and beams have been so set. Later that ornamentation, produced by the mode of execution employed by the workman, was carved in stone. In this manner most of the ornaments of arch-



architecture, which are not imitated from the plant kingdom, originate in the most natural means of execution.

If one desires to seek the origin of art forms of a conventional art like architecture, it is necessary to resort to practical means that remain the same for centuries, and to resolve to study those practical means, without which he will make many errors. Gradually instead of the modern bracket strengthening the end of the beam, and leaving it there so as to lighten it, he carved animals and heads, the lateral shavings lost their importance, but traces of them are still found at the sides.

Thus were carved most of the corbels of the abbey church of S. Sernin of Toulouse, which date from the 12 th century, and that have a singular energy of design. Here is one taken from the cornice of the south gate. (6).

The shavings disappeared completely about the middle of the 12 th century, as we have the proof in examining the cornice of the apse of the little church of Mas d'Agen (7).

The corbels remain beneath the cornice slab of the edifices of Poitou, Saintonge and Berry, until during the first years of the 13 th century. The beautiful arcade that closes the side aisle of the nave of the cathedral of Poitiers (1190 to 1210) is surrounded by a cornice, whose cornice forms a gallery and is supported by charming corbels ornamented by figures (8).

Stone corbels disappear from cornices during the 13 th century, and are rarely employed longer except as unusual supports of balconies, corbellings, tiebeams of carpentry or the main beams of floors.

Here (9) is a rich corbel found near the cathedral of Troyes, which dates from the beginning of the 13 th century and appears to have been intended to support a strong projection, for example like that of a balcony or the main beam of a floor. Then frequently in civil or military edifices are found strong stone corbels composed of several courses and exactly performing the function of an anchor of the carpentry under a main beam. Such are the corbels still in place in the high walls of gate Narbonne at Carcassonne (end of 13 th century), and that support the enormous thickness of the roofs of the two towers (10). The constructor certainly had here the idea of p



placing this stone member in accord with the wooden timber supported.

The hall of arms of the city of Ghent in Belgium has retained analogous corbels beneath its main beams (11), but much richer and exactly representing a tie resting on a corbel A fixed in the wall, bearing beneath the beam a cap B, just as would be practised in a carpentry work.

These rigid forms are rare in the 15<sup>th</sup> century, and corbels intended to support beams are rich in sculpture, frequently ornamented by figures and heraldic shields, but no longer retaining the appearance of a wooden timber, inclined or horizontal and fixed in the wall. Such are the corbels of the great halls of the castles of Comcy and of Pirrefonds (12), that support the tiebeams of the carpentry.

The machicolations common on the military works of the 14<sup>th</sup> and 15<sup>th</sup> centuries are supported by corbels composed of three or four corbelled courses. (Art. Machicoulis).

From the Romanesque epoch until the 16<sup>th</sup> century, the stone lintels of the doorways are generally relieved by corbels projecting from the jambs, so as to diminish the span and consequently the chances of rupture. When doorways have great importance in location and purpose, these corbels are decorated by very rich sculptures and are executed with particular care, for they always are placed near the eye. There exists under the lintel of the south gate of the nave of the church S. Serain at Toulouse two corbels of white marble. We give one (13) of them, which represents king David seated on two lions; traces of the side shavings again appear here in the form of a simple festoon. This sculpture belongs to the beginning of the 12<sup>th</sup> century. The lintels of the principal doorways of our great churches of the 13<sup>th</sup> century are always supported by corbels with extremely labored sculpture. We shall cite those of the doorways of the cathedral of Paris, of the north doorway of the church of S. Denis, and those of the cathedral of Rheims and of Amiens. Architects have generally caused the sculpture on these corbels of portals, of figures connected with the subjects placed on the jambs or the lintels.

Burgundy, so rich in fine materials, presents an extraordinary variety of corbels, and these affect forms that belong to that province. Without mentioning corbels frequently employed

section with the number in accord with the wooden frame a

The wall of the city of Genoa in Liguria has a relief of a building which bears its main beam (11), but which is not in the wall, bearing against the base a cap, and is only represented in a secondary work. These relief forms are rare in the 15th century, and corbels decorated as above are rare in sculpture, frequently occurring in the 16th and 17th centuries, and in the 18th and 19th centuries the appearance of a wooden lintel, inclined or horizontal and fixed in the wall. These are the corbels of the 18th and 19th centuries of Genoa and of Lombardy (12), and a copy of the frieze of the cathedral.

The architectural common on the relief work of the 15th and 16th centuries are represented by corbels composed of a series of four corbelled courses. (See. Lombardy). The Renaissance epoch until the 16th century, the series of the doorway are generally relieved by corbels composed of the same, so as to diminish the load and to diminish the chances of rupture. When doorway have been introduced in location and purpose, these corbels are decorated with relief sculpture and are executed with elaborate care. In many cases are placed over the door. These relief corbels are found in the north of the city of Genoa. The first one (13) is of the 15th century and bears the name of the artist, which represents King David seated on the throne. The corbel of the side shows a relief scene in the form of a relief. This sculpture belongs to the beginning of the 16th century. The lintel of the doorway is decorated with a relief of the 16th century and is always supported by a series of extremely elaborated sculptures. The relief of the doorway of the church of St. George, and those of the church of St. George, and those of the church of St. George. Architectural have generally been the subject of these corbels of figures, of figures, and of the subjects placed on the heads of the figures.

Corbels, so much in the materials, are placed in the form of corbels, and these relief forms are placed in the form of corbels, and these relief forms are placed in the form of corbels.

in cornices (Art. Corniche), those supporting lintels of doorways have a very remarkable character of strength. They are sometimes strengthened at the middle to oppose greater resistance to a pressure. We give (14) one of those corbels of the end of the 12 th century, that comes from the western doorway of the church of Montreale. later their mouldings are still more accented, as shown by Fig. 15.. (Corbel from one of the doorways of the side aisle of the choir of the cathedral of Auxerre, 13 th century).

In the 12 th century the arches of vaults are often supported by corbels. During that period of transition, it occurred that the constructors, according to the Romanesque system only built engaged columns to bear the archivolts of the transverse arches, and desiring to turn the diagonal arches to receive the triangles of the vaults, when the piers were erected, they no longer found a proper bearing to receive the imposts of these diagonal arches; then above the capitals of the transverse arches they set a corbel, that served as a starting point for the diagonal arches. Thus were constructed <sup>the</sup> vaults of the side aisles of the nave of church Notre Dame of Chalons, (16), and those of the side aisles of the cathedral of Sens. In the church of Montreal just cited, to not embarrass the sanctuary by engaged piers resting on the floor, the architect has not only supported the diagonal arches, but also the transverse arch supporting the two vaults covering the rectangular apse, on strong corbels deeply engaged in the construction. (17). In this figure is seen at A the wooden tiebeam set to resist the thrust of the arches during erection, and cut off, flush with the impost when that construction was sufficiently loaded.

In the 13 th century, when vaults are not supported from the pavement, they no longer rest on corbels but on consoles. (Art. Cul-de-Lampe). The stone corbel almost exclusively belongs to the Romanesque epoch, the 12 th and beginning of the 13 th centuries. As for the wooden corbels, i.e., the projections formed by the beams or joists from the face of the wall, it is found in all wooden structures until the epoch of the Renaissance. (Arts. Charpente, Maison, Pan-de-Bois, Solive).



**CORBEILLE.** Bell of Capital. Basket.

Generating form of the capital around which are grouped ornaments, foliage or figures that decorate it. At bottom the bell rests on astragal and it is surmounted by the abacus. (Art. Chapiteau).

**CORDON.** Band. Fillet.

Moulding composed of a single member extending horizontally on a vertical wall. It does not have the importance of the belt, which always indicates a level of the structure, for example, a floor or a story. The band is an intermediate member, whose place is only indicated by taste, so as to remove the nudity of too high vertical parts. Bands are only found in Romanesque architecture, for in Gothic architecture all horizontal courses forming a projection always have a real signification, and indicate a floor or level.

**CORNICE.** Cornice.

The crowning member of a structure of stone or wood and intended to receive the base of the roof. The cornice is one of the architectural members of the middle ages, that best indicates how much the principles of that architecture differ from those adopted by the Renaissance.

In Roman architecture the cornice belongs to the entablature, which itself belongs to the order, so that if the Romans superposed several orders in the height of a monument, they had as many entablatures as orders. Thus the edifice consisted of several superposed orders, as merely a scaffolding of edifices placed on each other. Further, if the Roman placed an order in the interior of a hall, he left it its entablature, i.e., its crowning member intended to receive the roof. That may produce a grand effect, but cannot satisfy the reason. Besides, in the Roman orders, which are derived from the Greek orders, the entablature by the form of its mouldings, its projection and the appendages accompanying it, clearly indicates the presence of a gutter, i.e., the base of a roof and the longitudinal channel receiving the rainwater running down the surface of this roof. What is the good of a gutter at mid-height of a wall, particularly on the interior of a ceiled or vaulted hall? They why the cornice? We have stated elsewhere



now the Roman was little disposed to reason on the enclosure of the decoration of his edifices.<sup>1</sup> We do not make this a reproach to them, but only state the fact; that since the Romanesque epoch the architects, however rude they were, applied principles very much opposed to those of the Romans, using various architectural members in their real function, dependant on the construction. From whence did they take those principles? Was this in their own feeling, by their sole faculty of reasoning? Was this in Byzantine traditions? That is what we shall not seek to decide. It suffices us for the fact to be recognized, and that is toward what will tend the examples that we shall give, so that no doubts in that respect can remain in the minds of our readers. First in examining the oldest edifices of the Romanesque epoch, we see that the architects have a pronounced tendency to erect them with a single order from base to top; scarcely do they mark the stories by a slight offset or band. This tendency is so marked, that they sometimes elongate indefinitely engaged columns, without taking into account the proportions of the Roman orders, and always make them support the upper cornice, (the true cornice), however high this may be above the ground. Omitting the architrave and frieze of the Roman entablature, the column directly bears the cornice, the useful and projecting member, intended to protect the walls against rainwater. That deranges the arrangement and proportions of the Roman orders; but as compensation it satisfies the reason. The Romans open arches between the columns of an engaged order, i.e., they place a first platband (architrave), and a second platband (frieze), and the cornice above an arch, that we do not prevent anyone from finding very beautiful, but which is absolutely contrary to good sense. Romanesque architects, perhaps in imitation of Byzantine architects, adopted arches for all openings or for relieving the walls; they frequently set on the exterior engaged columns, but no longer committed the fault of surmounting them by a complete entablature, only necessary when the columns are detached. The engaged column plays the part of a buttress (this is its true part), and its capital supports the projecting slab of the crown of the edifice, otherwise termed the cornice.

Note 1.p.319. See Discourses on Architecture. (Entretiens).

the same as little disposed to reason on the subject.  
 The character of his address. It is to make sure a re-  
 sponse in fact, not only state the fact; what state the Roman-  
 was which the speaker, however true they were, evoked  
 something very much disposed to those of the Roman, since  
 the spiritual members in their real function, repeat-  
 ing the constitution. From whence did they take these prin-  
 ciples? Was this in Pythagorean tradition? That is what  
 I shall endeavor to decide. It satisfies us for the time to  
 be satisfied, and that is toward what will tend the examina-  
 tion we shall have, so that no doubt is made respect to the  
 in the mind of our readers. First in examining the con-  
 stitutions of the Roman Empire, we shall see that  
 it was a recognized tendency to apply them with a single  
 eye to the fact; exactly as they were the stories of  
 things of the past. This tendency is so marked, that we  
 shall find account the proportions of the Roman empire, and  
 they will last support the Roman empire, (the true empire),  
 however that this may be above the ground. Omittit the prop-  
 erty and friends of the Roman empire, the other three  
 parts the cornice, the useful and profitable matter, internal  
 and external, but still useful matter, the Roman empire  
 and proportions of the Roman empire, but as a whole  
 it satisfies the reason. The Roman empire is a whole  
 as a column of an ancient order, i.e., they place a third part  
 of (architrave), and a second part (frieze), and the  
 cornice above an arch, that we do not prevent anyone from the  
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 in architecture, showed traces for all ornaments or for relief-  
 of the relief they frequently set on the exterior attached to  
 the wall, but no longer committed the fault of supporting the  
 a single architrave, only necessary when the column was  
 needed. The architrave will have the same as a column. It  
 is in the true arch, and its central support has a relief-  
 of the arch of the edifice, otherwise there is a  
 relief.

Here (1) is an example among a thousand of this so natural a principle of construction.<sup>1</sup> The cornice is here no longer a simple slab receiving the tiles of the covering; between the engaged columns this slab rests on corbels. The water falls directly on the ground without a gutter, and to find at the top of the wall sufficient thickness to receive the base of the roof, yet without giving to the wall a thickness useless at the base, discharging arches borne on pilasters or engaged piers A B and on corbels increase the thickness of this wall below the cornice. Each piece of the slab has its joint over each corbel, which is indicated by reason. If the Roman cornice is decorated by modillions (that represent corbels, ends of beams) as in the Corinthian and Composite orders, these are cut in the block of marble or of stone composing the cornice. That is a considerable work of removing stone; there is a complete want of accord between the apparent form and the construction. On the contrary in Romanesque cornices the ornamental appearance is only the actual result of that construction. Each corbel is a block of stone deeply sunk into the masonry, between the corbels is no more than a square stone slab, set just as are the metopes of the Greek Doric order. Then from one corbel to another rests a block of the slab. At certain distances the great engaged columns strengthen the construction by arresting all effects of overhang or derangement, that might finally be produced in a too great length of those slabs set only on the corbels. Such a cornice is easily repaired, since it is composed of members independent of each other, that can be removed and replaced without the need of scaffolds.

Note 1.p.320. From the apse of the church of Leognan, end of 11 th century.

The most beautiful examples of cornices composed of a simple slab resting on the capitals of engaged columns and corbels is found in Auvergne in the 11 th century. The cornice of the apsidal chapels of the church of Notre Dame du Port at Clermont is one of the richest; for not only the corbels and capitals are finely wrought, but the slab is ornamented by billets, and its middle surfaces between the corbels being decorated by a sort of sunken rosette. The spaces between the corbels are composed of black and white stones forming mosaics, and b



beneath the corbels extends a band of billets that clearly separate the different members forming the cornice from the surface of the wall. We give (2) the perspective appearance of this cornice; at A is the profile, and at B is one of the rosettes, sunk in the bottom of the slab.

This system of cornices is generally adopted in the provinces of the Centre, in all Aquitaine and Languedoc, during the first half of the 12 th centuries. In Burgundy the Romanesque epoch furnishes us with a great variety of cornices. Further, it must be stated, that cornices take the more importance and present projections the more pronounced, as they belong to provinces rich in hard materials. In Ile-de-France, Normandy and Poitou, men rarely employed before the 12 th century any but the soft limestones so easily quarried in the basins of the Seine, Oise, Eure, Aisne and Loire. These materials did not permit making the slabs thin and projecting. The architects mistrusted them, not without reason, and they had adopted the custom of erecting their buildings of small materials, i. e., all having about the same dimensions. From the quarries we were brought supplies of stones ready squared,<sup>1</sup> from 8 to 12 ins. in height with equal width and lengths of 18 to 24 ins. They arranged that all the architectural members could accord with these dimensions. One understands then that they could not give a strong projection to their cornices. The Romanesque monuments so common on the banks of the Oise present neither cornices nor projecting bands, and the entire effect produced by these architectural members is due to a very refined and judicious study of the relations between the plain and moulded parts of the structure. Burgundy on the contrary, supplied hard and thin stones, easily quarried in large pieces; thus in that province the cornices have energetic profiles and present varieties in composition not found elsewhere in France.

Note 1.p.323. This method is still followed in Poitou, Sain-tonge, Angoumois, and on the banks of the lower Loire, as well as in the department of Aisne.

On the side aisles of the nave of the abbey church of Vezelay (last years of the 11 th century) is seen a cornice constructed always according to the Romanesque principle, i. e., composed of corbels supporting a projecting slab; but its character nowise recalls the cornices of the provinces of the Centre.



As for style, it is very superior to them. We give it here (3) in all its details, seen in perspective and in section. The corbel is frankly emphasized, and it has all the characteristics of the end of a wooden beam; but its mouldings return before the slab so as to form an enclosure around the double rosettes, that are between these corbels like inclined metopes, as wooden panels held by means of tongues. The construction is perfectly in accord with the visible form; the corbels are long stones penetrating the masonry; the slab is wide and between the corbels are only square slabs of stone 8 to 10 ins. thick. There is truly the edge of the roof of carpentry resting on a masonry wall, and it is impossible not to find there the tradition of the wooden structure. But let us not forget that when the nave of Vezelay was built, there was scarcely a century since all great edifices were covered and ceiled with wood, and that vaults were an innovation. (Art. Construction).

Besides, this cornice is a unique example; for in the same edifice the walls of the high nave are crowned in a different manner. In brief, an interval must separate the construction of the top of the nave from that of the side aisles, the architects had time to reject already the traditions of carpentry to decorate the edges of the roofs, they invented a new cornice, very singular indeed, but that already emphasizes stone construction. It is so composed of equal blocks of stone forming a series of quadrant corbels ornamented by ears like crockets (Fig. 4). At A the section of this cornice is made between two corbels; at B is its front; at C its horizontal projection, and at D its perspective. There is the origin of the cornice frankly Burgundian, that only ceased to be used during the 13th century. a cornice whose corbels are set without intervals between them, and whose most general form is that given by Fig. 5.<sup>1</sup> The drawing of this cornice in horizontal projection gives a series of semicircles cut out between the corbels; these are then hollowed in quadrant form. In section these corbels are drawn as a convex quadrant as in Fig. 4, with or without crockets, which are the oldest; or as a concave quadrant with bewels like example 5, which are the most modern. Romanesque Burgundian cornices indicate advanced art of drawing, like all architectural members of that province, and particularly a very refined observation of the effects

...is very superior to that. We give it here (2)  
...in perspective and in elevation. The  
...is finished, and in the all the perspective  
...of a wooden beam; and its position is  
...to form an angle around the handle  
...between these console like inclined members,  
...held by means of hinges. The construction is  
...with the visible form; the console are  
...the masonry, and also in wide and  
...are only square above of stone 8 to 10 ins.  
...of the roof of a chimney rest-  
...and it is impossible not to find here  
...the wooden structure. But let us not forget  
...there was nearly a  
...were covered and called upon  
...and that which was in elevation (Fig. 100)  
...this cornice is a unique example; for in the same  
...of the high nave are placed in a different  
...an interval must separate the construction  
...the nave from that of the side aisles, the arch-  
...the side aisles and the triforium of the nave  
...the roof, they inverted a few  
...and the side aisle, and the side aisle  
...it is composed of small blocks of stone  
...of constant cornice ornamented by an  
...at the base of the cornice is made by  
...at B is the front; at C is the side or  
...is the cornice. There is the cornice of  
...that only ceased to be used  
...a cornice whose corbels are set  
...and whose most general form is  
...The details of this cornice in section  
...a series of semicircles and one below  
...are then collected in constant form. In sec-  
...as a convex corbel as in Fig.  
...which are the offset; or as a  
...which are like example 5, which are the  
...and especially a very refined ornament of the offset

produced by lights and shadows. Then the cornices, although altogether simple, have the appearance of strength and richness at the same time that satisfies the eyes; they crown the walls in a monumental fashion, producing a very piquant play of lights and shadows, that contrasts with the nudity of the surfaces. Before the 13 th century, one must go into the provinces of the Centre and of Burgundy to seek cornices of grand character and well combined. On the contrary in the North during the Romanesque period, the cornices are poor, project little (which is due to the quality of the materials, as we have previously stated), and little varied in composition. Still the cornice with corbels is found everywhere before the 13 th century; it is an adopted system and exceptions are rare. The Romanesque architects of the North even push the application of the cornice with corbels to its most absolute consequences. Thus the corbels being made to prevent the tipping of the slabs (they have no other reason for existence), and the pieces of stone forming those slabs not being all of the same lengths, and the corbels must naturally fall under the joints, it results that the corbels are spaced irregularly; their places are determined by the length of each piece of slab. It even frequently occurs that the moulding ornamenting the lower edge of the slab stops beside each corbel, and allows the vertical joint to be seen. That is further perfectly reasoned. The walls of the apsidal chapels of the church of Notre Dame-du-Pre at Mans are still crowned by cornices of the 11 th century, that are cut according to these principles.(6). The walls are built of small rough rubble, and the slab of the cornice is composed of pieces, some long and the others short. The corbels being set beneath the joints of that slab, are spaced irregularly. In our Fig. it is seen that the moulding of the slab exists only between the corbels and leaves the joint free. Here again are found the corbels with shavings recalling those of Auvergne (Art. Corbeau), which causes the supposition, that this species of ornamentation had a great success during the 11 th and 12 th centuries. In the example given by us (Fig. 6), it still seems that the sculptors have imitated that ornament without understanding its meaning, and have executed it in the most barbarous fashion; while the schools of the Centre after the 11 th century are remarkable for



the refinement and purity of their sculpture.

Note 1. p.326. From the chapels of Notre Dame of Dijon, of beginning of 13 th century.

On the banks of the Oise and Aine, from the 11 th century, there is seen to appear between the corbels and moulded slab of the Centre and of Burgundy, a course cut in form of a little arch or of sawteeth. There exists around the little octagonal chapel at Laon, that passes for a chapel of Templars, a very singular cornice from the beginning of the 12 th century, conceived after these ideas. At the angles (7) it rests on engaged columns ending in heads; at the sides are beveled corbels receiving the intervals between the triangles forming the ornamentation. The joints of this sort of frieze are found over the corbels, and a slab with a continuous moulding crowns the whole. On the corbels the spaces between the triangles are sunk in little arches with inclined tympanums, as shown by the section A made at the middle of a corbel.

The tradition of construction in wood still appears here. The corbels are cut as one would cut the end of a beam, then beneath the triangles one finds again the shaving produced by the carpenter in cutting a plank in form of sawteeth. However these last vestiges of wooden construction soon disappear in that province, so abounding in limestone materials suitable for construction, and the cornices with little simple or subdivided arches alone prevail until the end of the 12 th century; now these cornices no longer have anything that recalls construction in wood.

Here (8) is one of those cornices so common in Beauvoisis; it comes from the little church of Francastel (beginning of the 13 th century). In the same province about the beginning of the 13 th century the architects reject the little arches, but they still retain the corbels, and they commence to ornament the slab of the cornice by sculpture, we find an example of this on the nave of the church of S. Jean-au-Bois near Compeigne. (9).

If the banks of the Oise, Aisne and Seine between Montereau and Mantes, retain corbels beneath the slabs of cornices until the beginning of the 13 th century, i.e., until the frank application of the Gothic style, Champagne and Burgundy abandoned with still more difficulty that Romanesque tradition. Thus at

...entolace giant to ... ..

the top of the cathedral of Langres, 12 th century, we see a cornice in which the corbels assume a greater importance (10). The slab is alternately supported by moulded corbels and those representing the heads of men or animals. At the top of the porch of Vezelay, from about 1130, are already noted these alternations of moulded corbels and of heads. At the end of the 12 th century, around the choir of Notre Dace of Chalon-sur-Marne, the cornice again presents corbels with heads, others ornamented by rosettes, and yet others simply moulded. The slab already assumes more importance, and it is covered by a rich decoration of leaves. (11).

In Angoumois, Poitou and Saintonge, the cornice with corbels in the style of that of Auvergne, is reproduced until about the end of the 12 th century. (Art. Chapelle, Fig. 33, which represents a part of the apse of the church of S. Euthrope of Saintes.

In Normandy the Romanesque cornice is very simple and only presents a small projection from the face of the wall. Frequently it is composed only of a simple slab 4 to 6 ins. thick. Yet these corbels with or without arches are frequently found. These corbels sometimes rest on a decorated fillet, as around the apse of the abbey aux Dames of Caen. (12; 12 th century).

From all the preceding examples, one can conclude thus; that during the Romanesque period and in the different provinces composing the France of today, with very few exceptions, the cornice consists of a row of corbels supporting a projecting slab. We shall see how the lay architects of the end of the 12 th century adopted an entirely new system of cornices, yet borrowing from the Romanesque cornice something of its appearance, viz:- the alternation of lights and shadows produced by the projections of corbels more or less distant. First let us state that at the moment of transition, the architects neglected Romanesque traditions, and even sought to free themselves from these entirely. Thus around the cathedral of Noyon, whose construction dates back to about 1150, the cornices are no longer simple mouldings. The church of S. Martin of Laon, built at nearly the same epoch, shows us at the top of the choir a cornice only composed of two superposed tablets.(13). On the nave of the same church is found as the entire cornice a slab ornamented by rosettes.(14). At the cathedral of Senlis alrea-

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...the ... the ... (10).  
...is ... supported by ... and ...  
...the heads of men or animals. At the top of ...  
...from about 1150, the ...  
...of ... in the ...  
...in the ... around the ... of ...  
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...by ... and yet ...  
...already assumes more ... and is covered by  
...of leaves. (11).  
...in ... in ...  
...of ... in ...  
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...the ... very simple and only  
...from the face of the wall. ...  
...of a ... also ...  
...with or without ...  
...rest on a decorated ...  
...of ... (12; 13 century).  
...the preceding ... one can ...  
...in the ...  
...the ... when very few ...  
...of a row of ...  
...the ... of the ...  
...an entirely new ...  
...from the ... of its ...  
...the ... and ...  
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...the ... and even ...  
...entirely. Thus around the ...  
...back to about 1150, the ...  
...The ... of ...  
...the ... shows us at the top of the ...  
...of the ... as the ...  
...of ... (14). At the ...

already appeared about 1150 cornices with crockets; now these crockets are nothing but plant stems terminated by a sort of bud or bunch of leaves not yet expanded (Art. Crochet), and they fulfil the function of corbels very close together: only they no longer support the slab, that has become thicker and is independent.

If the architecture inaugurated by the lay school at the end of the 12th century essentially differs from Romanesque architecture, in the principle of construction, it perhaps varies still more by the infinite details, that enter into the composition of an edifice. Without analyzing them, Romanesque architecture followed the very confused traditions of Roman antiquity, Byzantine influences and local customs. For example, a cornice for Romanesque architecture is a projecting slab intended to remove from the walls the ends of the covering tiles, so that the rainwater may not wash the surfaces. The slab is simple or decorated; it is not always only one low course of stone, whose profile is given by caprice, but fulfils no useful purpose. If no tiles covered this profile the rainwater can run down the surfaces, for its section was not made as to drip, like the fascia of the Greek cornice. The architects of the epoch of transition left aside the Romanesque cornice with corbels; they also had no leisure to occupy themselves with those details; they thought of only one thing at first, which was to break with former traditions. But when they had solved the most difficult problems imposed by their new methods of construction (Art. Construction), they thought of applying to the details of architecture the rational principles that directed them. They desired no longer those roofs pouring the water directly on the ground as on lower structures, they thought with reason, that a cornice must support a gutter, so as to direct the water in certain channels arranged to receive it; that it was useful to make access to the coverings easy, to allow roofers to repair them at all times. Hence these Romanesque cornices projecting so little and so weak could not suffice for them, no more than the thin slabs placed on their walls, when they rejected cornices with corbels. Then they applied themselves to seek a form suitable for the purpose, that borrowed nothing from the traditions of the past. That form was found and quickly adopted; for thus one scarcely perceives

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... are nothing but plant stems ...  
... of leaves not yet ...  
... the ...  
... also, ...

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... essentially different from ...  
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... only one ...  
... with ...  
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... (Art. ...)  
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a transition, and indeed without its being possible to contest it, this new form abruptly appeared in Ile-de-France and Champagne, i.e., in the midst of that great school of lay architects, which at the end of the 12 th century established on new principles an architecture, whose forms were in accord with those principles, and consequently new.

One of the oldest existing Gothic cornices is that crowning the apsidal chapels of the cathedral of Rheims. It is composed of a course enriched by leaf crockets, and a second course whose section is a drip moulding. (15). But here still the lower course has a great importance compared with the upper course, the drip moulding recalls still the slab of the Romanesque cornice, and on its wash A at certain distances are left small horizontal surfaces, that Villard de Honnecourt terms blocks, that first allow the workmen to walk along the projection of these drip mouldings, and thus serve to divide the water falling from the roof or running down the surfaces, and to divert it from the joints, for it must be noted that these cornices do not bear gutters and gargoyles, but still allow rainwater to run off between these stone blocks. Indeed according to the project of Robert of Coucy, these chapels were to be surmounted by pyramidal roofs resting directly on the edge of the cornice.<sup>1</sup>

Note 1.p. 334. See Album de Villard de Honnecourt, annotated by H. H. Darcel. 1858.

Soon finding these drip mouldings insufficient, the architects of the 13 th century gave them a greater projection; a great height of the course. The upper cornice of the choir of the cathedral of Paris (16), rebuilt at the beginning of the 13 th century already shows us deep and strongly projecting mouldings A receiving a gutter leading the water to the gargoyles spaced at certain distances. A little after the setting of these cornices A, the architects of the cathedral added a second course B to the former drip moulding to give it a more vigorous appearance, and to avoid the thin place C, that might cause the fear of rupture. Already these drip mouldings A had been intended to support a balustrade, that was replaced when the second course B was set.<sup>1</sup> It will be observed that each c crocket ornamenting the first course D is carved in one block of stone, as if it fulfilled the function of a corbel. The c



cornices of the cathedral of Paris may be regarded as the most beautiful among those of the beginning of the 13<sup>th</sup> century; those of the facade present the unique peculiarity, that their drips are made in two courses, so as to give them a greater projection. Thus the cornice that crowns the gallery which surrounds the towers and connects them is composed of three courses; one course of crockets and leaves and two courses of the drip moulding (17); the upper course is pierced with holes at certain distances beneath the balustrade, to allow the water to run off and fall on the terraces. (Art. Cheneau, Fig. 2). The drip moulding here fulfils the purpose of a strongly projecting gutter, intended to remove the water from the surfaces.

Note 1.p.335. At the cathedral of Chartres are seen two drip mouldings superposed at the top of the chapels of the choir; it is evident that the architects of the beginning of the 13<sup>th</sup> century perceived by their experience, that in setting a thin slab on the first course of the cornice, but projecting far more than the Romanesque slabs, ruptures were produced. They first doubled these slabs, and then came to make them thicker.

Generally the drip mouldings are made in height of a single course; but the details of the western facade of the cathedral of Paris are of dimensions above the ordinary, and it seems that the architect to whom is due the upper part of that facade, i.e., the two towers with their open gallery (about 1225), desired to give the architectural members a relatively very great importance. The upper cornice of the two towers, intended to receive the bases of stone spires, whose construction was only begun, is unique in the height of courses in the old Gothic style. It is composed of two courses of crockets, each having a height of 2.5 ft. between beds; one of the drip surmounted by two courses with wash, and the balustrade set when the continuation of the spires was dropped. Each crocket is cut in an enormous block of stone, as shown by our Fig. 18; the courses of the drip and the wash above are cramped all around by double cramps A taking the place of the fourfold anchoring. One sees that the architect had taken precautions to be able to erect his spires without danger.

Still the drip mouldings of cornices of the beginning of the

...of the cathedral of Paris may be regarded as the last  
 ...of the beginning of the 13th century;  
 ...of the 13th century present the same peculiarity, that the  
 ...in two courses, so as to give them a great  
 ...the same time shows the early work  
 ...and connects them is composed of three  
 ...of crockets and leaves and two courses of  
 ...the upper course is directed with the  
 ...the distance, so that the  
 ...and fall on the terrace. (See Chapter, 111.  
 ...the purpose of a balcony  
 ...intended to remove the water from the sur-  
 ...

...At the cathedral of Chartres one sees two  
 ...of the top of the chapel of the choir;  
 ...the architect of the beginning of the 13th  
 ...by their experience, that inserting a  
 ...the first course of the crockets, but projecting  
 ...the crockets were produced.  
 ...and then come to make them

...the same way are made in the case of a single  
 ...of the western facade of the cathedral  
 ...of the cathedral above the doorway, and it seems  
 ...the lower part of the tower  
 ...the tower with their own (see 111).  
 ...the tower with their own (see 111).  
 ...The lower portion of the tower, 111-  
 ...the base of stone courses, whose construction  
 ...is made in the heart of courses in the old  
 ...is composed of two courses of crockets, each  
 ...between each; one of the two sur-  
 ...and the distance see  
 ...the tower was crossed. Each crocket is  
 ...as known by our 111.  
 ...the place of the tower  
 ...the tower without doubt.

13 th century probably appeared to have profiles too angular and rigid for architects already very advanced at the middle of that century, for at that epoch about 1240, we often see the drips on the last course of the cornice replaced by a less severe profile. A round with a projecting edge serves as a drip and replaces the drip moulding of the primitive Gothic corona. The cornice that crowns the tower of the cathedral of Troyes is one of the most beautiful, that we know of that brilliant epoch of Gothic art (1240), and it is covered by a round corona, profiled as we have just stated.

fig. 19 gives the ~~front and section of~~ that cornice. It will be noted that the joints A are skilfully arranged to combine with the double row of crockets, and to not cut across the sculpture, as so many of our architects fail to do today. Here the ornament is apparently continuous, but ranges perfectly the place for the vertical joint. About the same epoch, in the provinces into which the Gothic style and all its consequences penetrated with difficulty, as for example in Normandy, we see the Romanesque traditions persist beside the new forms. The cornice of the nave of the cathedral of Rouen, in that respect, is very singular to observe. One finds there the little Romanesque arcade combined with the crockets of the 13 th century surmounted by the rounded corona (20). It presents to us very judicious jointing, like all architectural members of that epoch.

The cornices offer few varieties during the course of the 13 th century; almost always they are composed of two courses; one in the form of a hollow decorated by crockets or leaves, the second bearing a projecting drip moulding. But the corona with a wash only exists if the cornice forms a gutter, for if (as frequently occurs in civil and military architecture) the roof gutter rests directly on the edge of the cornice, that is terminated by a vertical fillet ~~and not by~~ a wash. Thus the slates or tiles form a drip before that fillet, and the upper course of the cornice is itself profiled as a drip, to avoid all chance of injury on the surfaces, in case the roof gutter fails.

We give (21) one of those cornices so common during the 13 th and 14 th centuries in civil architecture, a cornice whose upper course at need serves as a drip, and whose lower course



is without sculpture and forms a great projecting round. There still exist on the palace of justice of Paris several cornices of that sort, that have a strong effect, though simple.

Now here is a pretty cornice composed of a single course forming a drip; it is placed at the top of the tower called of Justice at Carcassonne (21 bis), end of 13<sup>th</sup> century). The moulding is stopped at each joint strengthened by a projection forming a corbel. That is well reasoned, particularly when all the stones must be cut on the yard before setting, for then it is certain that the joints will show no offsets, and that the mouldings will not be cut crooked. The profiles of these cornices without wash are always cut so that the lower edge of the fillet forms a drip to drop water beyond the surfaces, if the first row of tiles does not perform that function. (22).

The 14<sup>th</sup> century generally retained cornices in two courses, and the only difference found between these cornices and those of the 13<sup>th</sup> century is, that the sections of the drips are leaner, and the ornaments, leaves or crockets, are more slender and dryer in execution. Yet it is <sup>un-</sup>necessary to believe, that the architects of that epoch may not have sometimes sought new combinations. Thus we see around the choir of the church S. Nazaire of Carcassonne (about 1325) a cornice, whose composition is as original as its execution is beautiful. That cornice returns to Romanesque traditions, i.e., it is composed of a row of corbels supporting a course forming a corona, but decorated by broad leaves between these corbels; it receives a gutter and a balustrade. Here (23) is the perspective detail of that cornice. At A is drawn its section between the corbels. Placed at a great height, this cornice produces much effect, because of the play of shadows and lights on these projections so frankly accented.

Here, contrary to the customs of the artists of the 14<sup>th</sup> century, the details of the sculpture are at the details of the monument; they do not dwarf the masses, but on the contrary emphasize them by rich and broad execution.

During the course of the 14<sup>th</sup> century, we see the crockets gradually replaced in the lower course of cornices by bands of deeply cut leaves, but whose irregularity and lean execution no longer gives projecting points equally spaced, those



those heads of crockets that at a distance have such a monumental effect, and still recall the corbels of the Romanesque epoch. We present (24) one of these cornices of the end of the 14 th century coming from the top of the north tower of the cathedral of Amiens. The cornices of the 14 th century, independently of the meager profiles and the dryness of the sculpture, generally have small projections, which then become necessary when all horizontal members were sacrificed to the vertical lines; but about the middle of the 15 th century, on the contrary the crowning cornices have an increased projection, often being composed of a considerable number of courses corbelled out, decorated by bands of leaves, so as to present easy passage at the base of the roofs. The leaves extend before deep hollows, separated from each other by fine mouldings, and the coronas recall the exaggerated form of the round drip moulding of the end of the 13 th century, i.e., the upper wash is concave, the round is flattende and terminates in a strongly projecting drip, the lower hollow being deeply sunk. (25).

At the beginning of the Renaissance is already perceived, particularly in civil architecture, a return to the forms of the Roman cornice; the Gothic drip moulding is omitted. Still it was only till about the middle of the 16 th century, that the Roman entablature reappeared in edifices. The beautiful cornice of the square tower of the chateau of Blois, built under Louis XII, still retains its Gothic members, with some details borrowed from the antique architecture. Above the row of recurved ovals is placed an arcade supported by corbels, that recalls the crowning machicolations of the strong castles of the 14 th century. On the arcade is found the course with a hollow decorated by leaves arranged like the crockets of the 13 th and 14 th centuries, then the drip of the 15 th century is scarcely changed.<sup>1</sup>

Note 1.p.343. See examples of decoration by L. Sauchere.

The city hall of Orleans, built in 1442 by master Viart and in spite of the date, which presents all the characteristics of that epoch of Louis XII, is crowned by a cornice of that kind, and that of the square hip roof of the chateau of Blois.<sup>1</sup> At the chateau of Chambord are still found the last traces of the cornice of the castle of the middle ages, with its arches in little niches representing machicolations



Note 1.p.344. See Arch. civi et dom. by MM. Verdier and Gattois.

We shall terminate this Article by giving some cornices of wood taken from civil structures. That first (26) is commonly found arranged at the base of the roofs of the houses of Troyes built of half timber work. This is one principle for a cornice adopted during the 14 th and 15 th centuries. Blocks form the corbels on the exterior above the plate, and carry a small plancher of boards under the furring. The other cornice (27) dates from the beginning of the 15 th century, and belongs to a modern house situated on Rue de la Savonnerie at Rouen. On a moulded plate A are set the little posts B that receive the joists C of the upper floor; the ends of these joists are relieved by the corbels D. Between these corbels are set little arches cut in a board, which forms a series of machicolations. On the ends of the joists rests the plate E of the cornice; the spaces G between the corbels are filled with planking.

#### CORPORATION. Guild. Trade Union of Masters.

An association or oath-bound guild (according to the ancient signification of the word "conjuratio") of artizans, united by particular agreements consisting of rights and reciprocal duties. There existed associations of trades under the Roman empire; they even claimed to have been established after Numa, and they were designated by the name of college or body of artizans. In the middle ages the mechanics, merchants and workmen of the cities retained the Roman traditions in the great southern cities, and the guilds did not cease to exist, while in the cities of the North they were scarcely seen to establish themselves till the moment of the enfranchisement of the communes, i.e., about the 12 th century. The kings took them under their protection, as one of the means for weakening the feudal power. Under S. Louis they were regulated at Paris by Etienne Boileau.<sup>1</sup> To become a member of a guild at that epoch, it was necessary to pass an apprenticeship that lasted more or less time, at the end of which one became a master. The masters exercised a sort of control over each other, consequently maintaining the price of work and the good quality of the products. Free competition did not occur then, and the merchants or artizans of the cities could only resist the tyranny of the lords by closely combining under the patr-



patronage of the sovereign. Thus they formed a powerful body which it was necessary to consider, and that by its organization itself assured to the sovereign certain resources regularly received. Membership was frequently obtained by money, which formed a resource for the treasury; or indeed also the king for a capital sum once paid, authorized the guild, which thus acquired the right of collecting certain dues on the import of merchandize, tolls on rivers and bridges, at the entrance of ports, etc.

Note 1.p.346. See *Règlements sur les arts et metiers de Paris rédigés au XIII siècle. Livre des metiers*, by Etienne Boileau. (Coll. d. doc. inéd. sur l'hist. de France).

To not wander from our subject, the body of the trades connected with buildings consisted in the 13<sup>th</sup> century of carpenters, masons, stonecutters, plasterers and quarrymen, statuary, painters and sculptors, bridge-builders. As for the masters of works, which we term architects today, they do not appear to have ever formed a guild; we cannot have even a very vague idea of their powers before the 15<sup>th</sup> century. We see that they were called to the cities to build edifices, and that to them were paid the commission fixed during the duration of the work (Art. Architecte); but did they have charge of the contracts made with the different chiefs of the workmen? Did they prepare specifications and estimates? Or regulate the accounts? All that seems doubtful. From the end of the 13<sup>th</sup> century, cities, abbots or chapters are seen to make contracts with the masters of the various trades without the intervention of the architect. He appears to retain an independent position and to incur no responsibility; in brief, he is an artist, who causes the execution of his works by workmen having no relation to him other than those of furnishers or jobbers to a general superintendent. The system of fixed prices was not generally employed, the workmen in each trade worked by the piece, the architect distributed the pieces, and probably a checker kept account of the work of each one. On the great inscription cut at the base of the south portal of the cathedral of Paris, the architect Jean of Chelles is designated by the title of stonecutter. Robert of Luzarches and his successors, Thomas and Regnault of Cormont, take the title of masters in the inscription of the labyrinth of the cathe-



cathedral of Amiens. It is certain that a mason or stonecutter could not conceive and cause to be executed the different parts of an edifice, in the erection of which the carpenter, smith, sculptur, joiner and glass painter must participate. And in Gothic architecture the various members of the construction and decoration are too intimately connected, that one can admit for an instant, that each trade can act independently without a supreme chief. One of the most remarkable qualities of that architecture is, that all is foreseen, all comes to set itself in the necessary and prepared place. Thus ahead is necessary to foresee and to give orders at the proper time. However that may be, if the guilds connected with building labored much during the middle ages, if they left remarkable traces of their skill, from the political point of view they did not take the importance of many other associations. One rarely sees them take part in the troubles of the communes, demand an extension of privileges, impose conditions, or form those powerful coalitions, that so long disquieted royalty.

COUPÉ DE PIERRES. Stonecutting.

See Arts. Appereil, construction, Trait.

COUPOLE. Dome.

A hemispherical vault, one generated by two curves intersecting at the crown, or by a half ellipse placed on a circular or polygonal plan, supported by four transverse arches or solid walls. The word dome was only employed after the invasion of Italian architecture in the 16<sup>th</sup> and 17<sup>th</sup> centuries; it is the Italian word "cupola" frenchified. The Romans from the time of the republic had built domes on circular walls, or those forming a great number of sides. But it was at Byzantium, that were erected by the emperors the first domes placed on pendentives. It is scarcely credible that the celebrated dome of S. Sophia was the first construction of that kind attempted. The attempt would have been very bold, since that dome has a diameter greater than all other vaults on pendentives that exist. Did the idea of constructing a dome on pendentives come naturally to the Byzantine architects after a series of experiments, or was it suggested to them by the study of oriental monuments unknown today? That is what we shall



not undertake to decide. it is certain (and to this we must restrict ourselves in this Article), that the Byzantine dome, for the architects of the first centuries of the middle ages, was a type that they sought to imitate in the West. Under Charlemagne was erected that of Aix-la-Chapelle in imitation of the dome of S. Vitale of Ravenna; but in these two examples the pendentives do not appear, and the domes start from the base. At Venice at the end of the 10<sup>th</sup> century were built on pendentives the domes of S. Mark, of that edifice was copied a little later at Perigueux. (Art. Architecture Religieuse, Figs. 4, 5). Yet before that time experiments with vaults on pendentives had been tried in the West. There exists at the eastern point of the island of S. Honorat on the shore of the Mediterranean a little church, whose construction appears to date back to the 7<sup>th</sup> or 8<sup>th</sup> centuries; it is the chapel of S. Ferreol, here is its plan (1) and the external elevation of the entrance end (2). It is difficult to imagine a more barbarous structure. On examining the plan, one sees at A the horizontal projection of a small dome with circular base; now the spaces B do not form a tunnel vault, as might be thought, but warped pendentives, so as to form a horizontal section for the dome A. The constructor simply warped the courses of a tunnel vault to arrive at that vault, which has produced a very singular jointing.

The internal view of the chapel (3) shows the arrangement of the courses of rubble that form the pendentives of the little almost conical dome surmounting them. If we make a section on the line C D of the plan (4), we see indeed that the dome is not a hemispherical or elliptical calotte, but a curved-conical one. We do not believe that there exists in the West a dome older than that of the church of S. Ferreol. And this example, which probably was not the only one, will indicate that the architects of the first time of Romanesque art were very much occupied with the idea of erecting domes on pendentives; for certainly there were twenty simpler procedures for vaulting the principal bay of this chapel, without the need of resorting to this means. There was evidently the idea of imitating those Byzantine structures, which then passed for masterpieces of the art of architecture.<sup>1</sup>

Note 1. p. 350. M. Verimee took care to draw this little mon-



monument, and has had the courtesy to furnish to us the precious sketches, that he made during his stay at S. Honorat.

The domes of the abbey church of S. Front at Perigueux can be regarded however as the first, whose construction has exerted a considerable influence on western architecture. Those domes, five in number, equal in diameter and height, and with circular bases, are placed on pendentives; but these pendentives are not jointed as proper; the beds of the courses are horizontal instiad of being normal to their generating curves—these are actual corbellings that are supported only by the adhesion of the mortar and by their spherical form. Thus it is evident that the architect of S. Front imitated the form of the foreign structure without taking in account its principle, and this fact alone tends to oppose the opinion expressed by our learned friend, M. de Verneilh, viz:— that the actual church of S. Front was erected by an artist brought from the shores of the Adriatic.<sup>2</sup> We have seen already in the preceding example, that the builder of the little church of S. Ferreol, desiring to build pendentives, has found no means to give them nearly the proper curvature, other than to incline the courses of rubble on the haunches of the transverse arches, i.e., to superpose courses of voussoirs, well or badly, by projecting them beyond each other, connecting them in the rudest manner at the point of junction. In construction and in everything requiring both calculation and experience, it must never be assumed that the simplest means were first adopted; the contrary occurred. The principle of construction of pendentives being once known seems very natural; but it must appear to the eyes of rude artists as a real feat. It was never understood by Romanesque architects, and if we possess in France some domes on pendentives before the Gothic era, those have only an appearance, not a system of construction understood and practised. Besides, the domes resting on the walls or on pendentives that exist in the East, and those of S. Mark of Venice, are either built of brick, of small tufa rubble, or of concrete composed of light stones and mortar; properly speaking, there is no jointing. These vaults are generally a casting on a form or a concretion of irregular materials made to adhere together by the mortar. Still today in the East, masons in closing a dome do not build a carpentry centering; they c



centering; they content themselves with a strip of wood fastened at the centre of the dome, which they move in all directions, building the masonry according to the radius given by this strip like a small plaster dome. In the West in spite of Roman traditions, construction in cut stone has replaced the construction in concrete and brick. It was then necessary to joint the pendentives. Where could be found pendentives jointed in stone? The domes of S. Mark of Venice are of brick, and under the mosaic the pendentives consist of discharging arches also in brick, turned over each other by means of centering, or which is more probable, to a rod, one end fixed at the centre of the generating sphere of those pendentives as shown by fig. 5. We do not know if the pendentives of the dome of S. Sophia of Constantinople are thus constructed; it is probable, for that corresponds to Roman traditions. If that be so, pendentives jointed in stone, i.e., whose beds are normal to the generating spherical curve are a very modern invention, that does not date earlier than the 16<sup>th</sup> century, and the pendentives of the first centuries of the middle ages are only corbellings or arches superposed in a spheroid. These technical observations have more importance than often believed, for they aid in explaining the transformations and influences, of which one cannot render an exact account, if they are neglected.

Note 2.p.350. It must be stated, that when M. de Verneilh published his book on Byzantine architecture in France, M. Abadie, the architect charged with the restoration of S. Front, had not commenced the work that he directed with so much devotion and intelligence, and this fact of the singular construction of the pendentives had not been mentioned.

It is very strange that the western Romans did not invent the dome on pendentives, or if they did invent it, that no trace of it remains to us; for they had caused the penetration of cylindrical tunnel vaults into spheres, and pendentives are nothing but curvilinear triangles of the sphere left between those penetrations. Yet the dome of S. Sophia, those of S. Mark of Venice and those of S. Front of Périgueux, are not only spheroids penetrated by cylinders. There is first a primary spheroid on the four piers, that is penetrated; then above these intersections is a second portion of a sphere with elevated centre. This clearly distinguishes the Byzantine from



the Roman dome. To make our definition understood by a Fig.(6); let A be the horizontal projection of a dome placed on four piers and four transverse arches. The section on the axis C D of this dome will give in vertical projection the profile E, but the section on the diagonal G H will give the revolved section I. On this principle were traced the domes of S. Front of Perigueux. The four transverse arches being composed of broken curves, the constructors were let to trace the spheroid penetrated by these arches by two lines drawn with the compasses, G K and H K. The horizontal section of this primary spheroid was made at L, and a projecting band was set at this level to support the false centres intended for constructing the dome. This dome itself is not a hemisphere, but is obtained by means of two curves. Regularly, these pendentives should be jointed in section according to the diagonal, conformably to the trace M, i.e., to present rows of voussoirs with beds normal to the curve H K, with horizontal tails; the constructors of S. Front did not take that trouble, and were contented to set the courses of those pendentives by corbelling according to the trace N. Due to the curvature of the pendentives, these corbelled courses of stone did not tip; but they might crush the point of the triangle and detach themselves in one piece from the transverse arches, which occurred. As for the dome proper, it is composed of a sort of drum O, consisting of horizontal courses and a calotte surmounted by slabs with a load at the apex. At S. Front the transverse arches are thin and their faces are vertical, the pendentives only commencing their curvature on the extrados of these arches. But soon the constructors thought and not without reason, that if these transverse arches supporting an enormous load, it was necessary to give their voussoirs long tails; but to not raise the pendentives excessively, or to give them a strong inclination, they caused the voussoirs of these transverse arches to enter into the first spheroid. Then being embarrassed to know how to arrange the two transverse arches on the projecting angle of the pier, they wished to separate both as soon as possible; for this purpose they lowered the centres of these transverse arches below the level of their imposts, and thus inclined their curves from the imposts. In the church of Souillac, whose construction is later than that of S. Front, the



architects have already adopted these modifications. At P we give the plan of an angle pier of that church, with the horizontal projection of the transverse arches and one pendentive; at R is the vertical projection of this angle, and at S a perspective view.

We no longer see domes with pendentives appear outside the western provinces during the Romanesque epoch, and in those provinces themselves at the end of the 11 th century and the beginning of the 12 th, trumpets or corbellings very often replace them. The pendentives were evidently an importation not perfectly understood by the constructors, and whose jointing always caused a certain mistrust in architects, when they had to erect great edifices. But on the banks of the Charente one finds a quantity of little churches with domes on pendentives, well conceived and well executed. It suffices to present here a single example (7), taken from the church of Montmireau, 12 th century. Here the transverse arches form a part of the pendentives, and the faces of their voussoirs are skew to conform to the curvature of the lower spheroid, as we have previously indicated in regard to the domes of Soulliac. The church of the city of Montbron, situated east of Angoulême, and which is far from the province where the dome on pendentives was generally adopted, already shows us no longer a hemispherical calotte over the crossing, but a dome with eight sides supported on four trumpets surmounted by projecting corbels.(8). This method was generally followed during the 11 th and 12 th centuries in Limousin, Auvergne, and part of Lyonnais, and even in Nivernais.

The dome that crowns the centre of the crossing of the church of Notre-Dame-du-Port at Clermont (11 th century) is on neither a circular nor an octagonal plan, but it partakes of both forms. The constructor has experimented. He commenced by passing from the square to the octagon by a course A (9) set as a corbel; on that course he has placed a sort of trumpet, and then has turned a small arch B on corbels. All that does not form a regular polygon, but an octagon with four large and four small sides. On that base he has erected well or badly an irregular octagonal dome with rounded angles, as shown by the plan. This dome is perfectly abutted at the side next the nave by a tunnel vault, whose crown rises above the open arca-



arcade D, as indicated by the dotted line. But the tunnel vaults and the trumpets are much lower, and the constructor feared the thrust of the dome toward the transepts. To avert that thrust he found nothing better than to establish two half tunnel vaults C, that spring from the arches E turned on the extension of the side walls of the side aisles, and beyond he was able to erect his transept G. At first sight this construction is singular, complicated, particularly in referring it to the epoch when built (11 th century); one asks where the Auvergnats obtained the examples, which served them as models.

We are little disposed to accept absolute systems, when this concerns the history of the arts, and we believe that at all epochs, those that occupied themselves in works of understanding were subject to very diverse influences, contradicting each other, and that what frequently appears to us to satisfy the conditions of unity of style and conception, because of the distance separating us from those times, is merely a mixture of incongruous elements. It is the same with works of art as with those animals in a menagerie, that one sees only at rare intervals and in small numbers; those of the same species all seem to resemble each other; but if one collects them and lives in the midst of them, he soon comes to distinguish individualities, to find a particular aspect in each one. If one brings a hundred negroes from Sennaar, you cannot distinguish them separately on the first day, but if you remain among them, you will soon find that between two negroes are as many differences as between two white men; you will find relations and resemblances of father and son. Well! The same phenomena are produced (if we may be allowed the comparison) when it concerns monuments of art far removed from us by the taste that erected them, or the space of time separating us from them.

Let us analyze this church of Notre-Dame-du-Port, one of the most interesting monuments of France, and we shall find very diverse origins, although this little monument may have for us today a character of apparent unity. The plan (Art. Architecture Religieuse, Fig. 9) is that of a Roman basilica with side aisles behind a sanctuary and four apsidal chapels; now in the 11 th century the architects scarcely had to guide them only the Roman traditions of the arts of the East. The church of S. Sophia of Constantinople was for these artists

[illegible]

a type, an incomparable work, the supreme effort of human intelligence. After the renaissance of the arts under Charlemagne, men on the good part of the European continent believed that they could do better, than to approximate the Byzantine types, or at least to be inspired by them. Well! If we examine the sections of the church of S. Sophia, we see that the great central dome is abutted lengthwise by two half domes or quarter spheres, and that in the other direction, i.e., that corresponding to the transepts of our churches, that dome is abutted by a series of flying buttresses that strengthen it, absolutely as the half tunnel vaults of the modest church of Notre-Dame-du-Port strengthen its little dome. Below the dome of S. Sophia and under that of Notre-Dame-du-Port of Clermont, we see the lateral walls pierced by arches. At S. Sophia that arcade is an architectural arrangement of great richness; at Notre-Dame-du-Port, these are three modest arches supported by two little columns. At bottom the principle is the same, and it must be said in praise of the Auvergnat architect, that while inspired by the principle of construction of an immense edifice, he knew how to adapt himself to the scale of his modest church, and to not reproduce at a small scale forms suitable for a vast structure. The dome of the church of Notre-Dame-du-Port is not supported on pendentives, like that of S. Sophia, it is true; but we have just seen that the western architects, even in applying this system of construction, never understood its mechanism. The Auvergnat school of the 11<sup>th</sup> century had its methods, and was very advanced in the way of the arts; it had scrupulously retained some remains of Roman traditions; it did nothing without perfect knowledge of the subject (and the good preservation of the edifices erected by it proves this), and probably not understanding the system of construction of pendentives, it preferred to employ the practical means known to it, of which it was assured; which further did not prevent its architects from taking from the East what their intelligence permitted them to seize as readily. To summarize, we believe that one can see in the church of Notre-Dame-du-Port the plan of a Roman basilica, on its crowning transepts being erected a structure, that presents all the elements constituting the structure of S. Sophia. From which, one can conclude, that in these Romanesque churches of the



Centre of France Byzantine influence is at least as marked as in the church of S. Front, which on the whole is an imitation of S. Mark of Venice, that itself was a copy of a Byzantine edifice of which a trace is no longer found. We think that the domes in the West have their origin in oriental architecture, that of the West as well as that of the Centre or that of the Rhine and of Germany, and that if one desires to find somewhere a local Romanesque architecture, it will be necessary to seek the provinces of the North, in Ile-de-France and Normandy. Certainly pendentives have a major importance, but do there only exist in the ancient empire of the East domes on pendentives? Greek churches, a quantity of small monuments of Georgia and Syria have domes without pendentives, borne on trumpets, arches, niches or drums, are these less Byzantine than the church of S. Sophia? And is it well reasoned to say? "What distinguishes the Byzantine dome from other domes are the pendentives; then all domes supported otherwise than on pendentives are foreign to Byzantine influence." It should be said, "foreign to the influence of S. Sophia or of S. Mark of Venice," but not to Byzantine influence, again we have just presented, at least we believe so, that although the dome of the church of Notre-Dame-du-Port may not be on pendentives, yet it can be a daughter of S. Sophia. It has been already stated; that when it concerns the recognition of the influences that act on the development of the arts, especially after Grecian antiquity and after the Romans and Byzantines, i.e. in regard to a considerable mass of traditions, it is prudent to analyze the productions of the middle ages with the greatest care, and to not hasten to adopt or reject some of these influences, for nearly all act, at least in the Romanesque era.

Since we are now on this chapter, domes furnish us with the proof of the force of those traditions accumulated in spite of those affected by them. Thus we have caused to be seen in several Articles of the Dictionary, and particularly in Art. Construction, how the architects of the primitive Romanesque epoch were compelled to place vaults on the plan of the Roman basilica, and how they attained this after many fruitless attempts. This problem solved (and solved by western architects, it must be said), the plans were modified in their general arrangements, but the mode of vaulting the naves made rapid



progress until the Gothic epoch. The Roman tradition of the plan persisted. There arose the influence of the dome in the midst of the work of these constructors; did the western architects that desired to submit to that influence necessarily modify the Roman plan? Not at all! They retained it and perched the domes on the crossings of their basilicas. At Pisa in the 12<sup>th</sup> century we see the constructors retain the Roman arrangement of the basilica, and cover the naves by carpentry at the same time that they erect a dome over the transverse aisles. Yet this was to place a vaulted monument on a monument commenced to not be so, it was to superpose two edifices, as if one wished at the same time to retain the trace of all opposed influences that they obeyed. In our time M. Quatremere de Quincy says with reason in his *dictionnaire historique d'architecture*: - <sup>1</sup> "We cannot help regarding the superposition of modern domes on the centre of the naves of a great church, and seen particularly from the exterior, as an actual superfluity and an architectural pleonasm. In fact if afar and seen from outside the city, these pyramidal masses produce agreeable effects, one is compelled to confess, that seen from near at hand, they produce no idea other than that of one edifice mounted on another, frequently with nothing connecting them, and above all that requires this. let us add that in the interior one can only see a duplication of motives, forms, of entirety of effect." Thus eight or nine centuries after two opposed traditions have exerted an influence on architecture, here again is an author, who without considering these different origins notes their discordance, recognizes two principles present, two principles that nine centuries of effort have not been able to combine. Still let us say that the first attempts have not been the least good, and that if the dome of the Pantheon of Paris presents with the rest of the edifice duplex motives," that we feely admit, if motives could be accused of dupilcity, one cannot say as much of the domes of our pretty Romanesque edifices of Angoumois and Perigord, that are placed on structures arranged from the base to receive them, and which on the exterior as the interior, are properly joined to the lower parts.

Note 1.p.339. See Art. Coupole).

But let us proceed. While in the West of France we see the



dome on pendentives take root and develop, while in the provinces of the Centre men seek to place it on trumpets, corbelling or corbels; in Provence at the beginning of the 12 th century the dome also crowns religious edifices. In Auvergne on the plan of the Latin basilica is placed the dome; In Provence this is on the Roman plan borrowed from the halls of the baths, composed of bays with internal buttresses, on plans that approach the edifice known at Rome under the name of basilica of constantine, that is planted the dome. The church of Notre-Dame-des-Dons at Avignon, though mutilated today, presents us with an example of the invasion of the dome on plans nowise arranged to receive it. The single nave of Notre-Dame-des-Dons is composed of rectangular bays with tunnel vaults on pointed transverse arches maintained by enormous buttresses, between which now open internal chapels. Here (10) is the plan of three of these bays, the church only comprising six of them. On the next to the last instead of a tunnel vault are eight round longitudinal arches, corbelled out on each other, resting on the two great transverse arches as indicated by the dotted lines K L on our plan, so as to attain the perfect square A B C D. In the interior of the square four small pendentives form the octagon. On this base rises a small dome, whose hemispherical calotte rests on eight columns between which open the windows. We give (11) the section of this construction on the transverse line E F, a section that will avoid long explanations. On the exterior this dome is a little octagonal edifice appearing to rest on the stone slabs forming the covering, and not connected in any manner with the rest of the church. At the church of the Major at Marseilles, is found an arrangement similar to this.

We must then verify here again the Byzantine influence (for this dome of Notre-Dame-des-Dons perfectly recalls certain small Greek domes) coming to mingle with Latin traditions. If we transfer ourselves from the banks of the Rhone to the banks of the Rhine, we shall also find monuments of the 12 th century in which the dome appears, and this is always the Byzantine dome, although it may not be raised on pendentives. But at first let us make an excursion to Athens. One of the largest churches of that city is the church of S. Nicodemus,<sup>1</sup> of which we give the plan (12), also conforming to most Greek plans.



A single dome surmounts the centre of the edifice. If we make a section on the line A B, here is the trace obtained (13); f four niches or rather four corbelled angles, pass from the construction of the square to the circular plan that receives the calotte by means of oblique tympanums or eight scarcely apparent pendentives, that surmount the arches. There the construction has not dared to attempt the four pendentives and has replaced them by merely four niches, that correspond to the trumpets so common in our Romanesque structures of the West. Well in the cathedral of Worms, we see a dome (the eastern) constructed according to this mode. The only difference between this structure and that of church S. Nicodemus of Athens is, that at Worms the dome is octagonal instead of being hemispherical, but the artifice employed in the construction of the dome of S. Nicodemus to transfer from the octagonal to the circular plan could not be admitted in the great church of Worms, where the dome rests on four transverse arches instead of being supported from the ground; further the construction of the eight oblique tympanums over the transverse arches and trumpets would have occasioned difficulties in jointing, with which the architects of the Rhine were not familiar. Examining this last construction with some care, do we not see that the triangle A B C beneath the diagonal arch is an actual pendentive by its form if not by its jointing? For the beds of the courses are horizontal.

Note 1.p.360. See *Choix d'églises Byz. en Grece*, by A. Couchard. 1842.

From all that precedes one may conclude; that in western Romanesque architecture, that beside the persistent Latin traditions are found almost everywhere a Byzantine influence evident by the introduction of the dome. But why reject such an influence in the mode of construction, when we see it manifested in such an imperative manner in sculpture and painting during the 11<sup>th</sup> and 12<sup>th</sup> centuries?

Yet if the architects of Auvergne, of the West, South, and the banks of the Rhine adopted as well or badly, the eastern dome to edifices Latin in plan (S. Front excepted), those belonging to the schools of the North did not allow themselves to be led to that mode, at least in their constructions; for as for the ornamentation, statuary and painting, on the cont-



contrary, they sought to approach the oriental types. (Arts. Ornament, Sculpture, Statuaire). But in the arts as in all else in the world, there are transitions, one submits frankly to a foreign influence, another resists it absolutely, a third endeavors to use that influence as a means of expressing the ideas belonging to it. Precisely at the limit separating edifices with domes from those without them, there is in France a unique monument, foreign, in which are found, so to speak, influences of oriental art with the methods of construction adopted in the North at the beginning of the 12th century, this is the church of Loches.<sup>1</sup> This church with a single nave is divided in four bays with square plans, on the two end bays rise towers (Art. Clocher, Fig. 27); but on the two intermediate bays, instead of domes or cross vaults are hollow pyramids borne on corbellings and covering the nave (15). One can imagine the effect produced by an interior vaulted in such strange fashion. Those enormous hollow pyramids, dark at their summits, cause an indefinable feeling of terror. The great corbelled triangles that serve as their bases are only the prolongation of four sides of those pyramids between the transverse arches and the side arches. Here at least the construction is not in accord with the form; for hollow pyramids composed of courses with horizontal beds form one of the most stable structures, that it is possible to combine. For the domes of the West the architect of the church of Loches has substituted the hollow pyramids of the towers of the 12th century, thus he avoided thrusts, and he applied a mode of construction, which was familiar to him, in the plans of those churches so common in Saintonge, Angoumois and Perigord.<sup>1</sup>

Note 1.p.34. If an edifice should merit all the care of the administration, that is the church of Loches; this is a monument unique in the world, complete, and with a rude beauty. It is to be regretted that it is almost abandoned, although its preservation is of the highest interest for the history of the art.

Note 1.p.367. If this curious edifice were found in Italy, England or Germany, it would be known, studied, praised, and probably preserved from all chance of destruction, an interesting one of the most extraordinary conceptions of Romanesque art. Unfortunately for it, it is in France at some miles from



the banks of the Loire, left to the restorations of the architects of the locality, who are far from suspecting its importance from the point of view of the history of art, and who cannot appreciate its strange beauty. For it must be stated, that the construction of this monument is executed with care, that the sculpture and mouldings are in the most beautiful style.

The dome disappeared at the moment when Gothic art was formed; yet the provinces in which this mode of vaulting edifices had been generally applied could not entirely forsake its influence, and we see in Poitou and the provinces of the West, the Gothic cross vault again subject to this influence. (Art. Construction; see the examples presented in Figs. 61, 68).

#### COURONNEMENT DE LA VIERGE. Coronation of the Virgin.

The coronation of the Holy Virgin is one of the subjects frequently represented by the sculptors and glass-painters of the 13<sup>th</sup> century in cathedral churches and even parish churches. At that epoch (13<sup>th</sup> century) the adoration of the Virgin had assumed great importance compared to what it had previously been, the most cathedrals that the bishops erected then in the North of France were placed under the name of the mother of God. Naturally the sculptors must relate her story in those edifices; and among the subjects preferred, her triumph, i.e., her coronation in heaven took the first place. There is seen a coronation of the Holy Virgin on the tympanum of the central portal of the cathedral of Laon, begun in the 13<sup>th</sup> century. There Christ blesses his mother with his right hand, and holds the closed book of the gospels in the left hand. At Notre Dame of Paris exists a magnificent coronation of the Virgin on the tympanum of the left portal of the western facade (about 1215). There is another above the lintel of the little red doorway of the same church on the north side. (about 1260). On the principal facade of the cathedral of Sens is one of the oldest coronations of the Virgin (end of 12<sup>th</sup> century) and one of the most beautiful in style. At the cathedral of Rheims on the gable of the central portal, the same subject is represented in colossal dimensions. At the portal of Calende of the cathedral of Rouen (14<sup>th</sup> century) is to be seen a coronation of the Virgin at the apex of the



gable; two angels and two seraphim are placed at the sides of Christ and his mother. At the right portal of the facade of the cathedral of Sens (14 th century) is sculptured a coronation of the Virgin; angels are placed in the voussoirs.

In these different representations the Virgin is seated at the right of Christ, and nearly always on the same seat. She joins her hands and slightly inclines her head; Christ himself places the crown on the head of his mother, or blesses her while an angel from a cloud brings that crown. Two angels erect or kneeling, holding torches, are present at the divine scene. At the red doorway of Notre Dame of Paris, there are a king and queen kneeling at the side of the personages, probably S. Louis and his wife the queen. We shall have occasion to review these sculptures in Art. Vierge Sainte.

#### COURTILLE. Garden.

An old word meaning a garden. (See Sauval, Antiquities de Paris. Vol. I. p. 67).

#### COURTINE. Curtain. Wall.

A defensive wall bearing battlements and a gallery, connecting two towers. (Old French Poem).<sup>1</sup>

Note 1. p. 368. Roman de Gorin le Lohereain. Vol. I. pa 169. Edit. Techener. 1833. Duconge thus explains the word "oleotrs", the gallery that serves as the upper defense of the curtain. (Latin text).

The curtains of fortifications of the Romanesque epoch are thick and solid, composed of concrete with facing of cut stone, or more frequently of small roughly cut rubble, the gallery is wide; sometimes even these curtains were terraced, and their height including the battlements rarely exceeds 19.7 ft. from the external ground, or the bottom of the ditch. From the 11 th century the curtains were equipped with wooden defensive galleries at top. In the 13 th century the height of the curtains was increased, and we see them attain a height of 32.8 or 39.4 ft. in very strong places. They were then sometimes pierced by slots at their lower part, to see what passed at the bottom of the ditch and to send crossbow bolts at the assailants. The means of undermining being very perfected during the 13 th century, slots pierced at the base of the curtains



were generally renounced, for their long openings indicated to the assailants the weak points of the wall. In the 14 th century the curtains again became solid at the base, and the entire defense was made at the top, which at that epoch was equipped with stone machicolations with parapets and battlements, covered or uncovered. When cannon began to play an important part in the attack of places, slots or embrasures were again pierced at the bases of the curtains to sweep the bottom of the ditch. Then about the end of the 15 th century, the curtains were terraced inside, as much to resist breaching batteries as to place the artillery at the level of the galleries. In the 16 th century were frequently arranged before the curtains and at the level of the counterscarp of the ditch, external ways with battlements, suited to receive crossbow men to sweep the glacis of the ditch. Romanesque curtains have their external faces vertical and without batter to make scaling more difficult. About the end of the 12 th century, frequently the curtains have slightly pronounced slope at the base, as much to prevent the approach of rolling towers as to place the assailant directly beneath the wooden defensive galleries. This method is followed during the course of the 13 th century. When the stone machicolations replaced the wooden defensive galleries, the constructors traced the section of the curtains so that projectiles falling through the holes of those machicolations, struck the batter at about 10 ft. from the ground, then rebounding on the slope of the glacis, struck the assailants obliquely, thus killing and wounding a greater number, than if they had fallen vertically. To resist balls a batter was given to the faces of curtains about the end of the 15 th century, and since then until recent times this method has been followed. (Arts. Architecture militaire, Bastille, Chateau, Creneau, Donjon, Hourd, Machiculis, Siege).

#### COUVERTURE. Covering. Roofing.

A covering of stone slabs, tiles, slates or lead, intended to protect vaults or carpentry of an edifice from rainwater. (Arts. Ardoise, Charpente, Dallage, Plomberie, Tuile).

#### COUVRE-JOINT. Batten.

A simple or moulded strip of wood covering the joints of a



ceiling or wainscoting composed of boards assembled by laps, tongues or butted, for wooden vaults or internal woodwork. Fig. 1 gives several sections of battens of ceilings under a roof.

#### COYAU. Furring. Block.

A little piece of wood nailed at the ends of rafters to lessen the slope of the roofing at the point where it is placed on the cornice. Fig. 1 presents at A facings placed at the feet of the rafters of a wooden roof. The furrings have the advantage of separating the junctions of the principals and rafters with the tiebeams B and the blocks C as well as the plates D. They prevent these different timbers and their joints from decaying by contact with the stone, by allowing air to circulate around them. (Art. charpente).

#### CRAMPON. Cramp. Anchor.

A piece of iron or bronze connecting two stones together. Fig. 1 is one of those iron cramps set with lead so frequently employed in the structures of the 13 th century; they take then the places of through anchors; they are generally of iron 0.8 x 1.2 ins. with lengths of 11.8 to 15.7 ins. (Art. Chaînage).

#### CREATION. Creation of the World.

The creation of the world is frequently represented in sculpture on the portals of churches of the 13 th and 14 th centuries, and in glass painting. We have stated elsewhere (Art. Cathédrale), that the great churches built at the end of the 12 th century and the beginning of the 13 th by the bishops of France in place of the old Romanesque cathedrals, contain a great multitude of believers, and to offer the people of cities vast covered areas suitable for assemblages, civil, political or religious, were covered by sculptures and paintings on glass, which represented the scenes of the Old and New Testaments, prophecies and legends, and presented to the multitude a veritable encyclopedia of the state of human knowledge at that epoch. Naturally the creation, zodiacs, labors of the year were not forgotten, and are most frequently sculptured on the portals of cathedrals. One of the most remarkable



representations of the creation is cut in the voussoirs of the great opening on the right of the western facade of the cathedral of Raon (beginning of 13 th century). The subjects commence at the left; the first (1) represents God thinking of the work to which he is going to devote himself; he seems to count the number of days required for him to complete his work. In the second compartment, placed over the first, God creates the celestial hierarchy; in the third he separates the land from the waters, in the fourth he forms the heavens, in the fifth the earth, under the form of planets; in the sixth, he creates the fishes and birds; in the seventh men and quadrupeds; in the eighth, God is seated and sleeping with his head leaning on a stick. The ninth subject represents the angels and men adoring God; they appear to admire his work. The tenth subject indicates human destiny. A personage of great height and crowned holds on his knees two other small persons, also crowned, who worship him. Two angels bring crowns at the right and left of the principal personage; these are the elect sheltered in the bosom of God. Beneath his feet a great demon's head devours a nude man, this is hell and its victims. Very beautiful reliefs are seen, representing the creation, on the substructures of the left portal of the cathedral of Auxerre (end of 13 th century). The subjects of the creation are found sculptured at the cathedral of Rouen on the portal of the library (14 th century). At Chartres and Rheims are also found a beautiful series of the same subjects sculptured beneath the voussoirs of the portals.

#### CREDENCE. Credence. Table.

Tables or tablets placed around altars to receive various articles required for the sacrifice of the mass. Thiers <sup>1</sup> says that in his time most altars of cathedrals had no credences, but that "those of other churches possessed them, some two, one at the right and the other at the left; several altars had only one on the right, i.e., on the epistle side." He adds:—"Only the credence on the epistle side serves for placing the chalice, the cruets, the book of the epistles and gospels, etc. That on the left serves for nothing, unless to produce symmetry, or at most to place some candlesticks and flowers." In the middle ages, when the love of symmetry was not carried to



the point of placing furniture, a table or cupboard opposite each other to satisfy a vulgar mania, men simply followed the primary rubrics of the Roman missal, that only desired a credence at the epistle side, also they suggest that this might be omitted if there was a window, a recess for support near the altar, where could be placed the hand bell, cruets, basin and towel, that served during the mass.<sup>1</sup> "The ceremonial of the bishops," continues Thiers, "also requires but one, no more than Gavantus, the other ceremonials and the other rubrics; yet they say that one should only use these at solemn masses, and not at other masses. But anciently credences were known neither to the Greeks nor the Latins." Anciently is a little vague, and we find credences above the piscinas or beside them in churches built in the 12th and 13th centuries on the epistle side. (Art. Piscine). These credences often have the form of little cupboards and are little recesses cut in the wall with a table of stone in front. Yet here is a credence from the middle of the 13th century, that is found placed in the arcade of the chapel of the Virgin of the cathedral of Seez, Fig. 1. The tablet projects little and is furnished with a little ledge as indicated by the section A; but the place occupied by it is well marked and richly decorated. In the 15th century the credences near altars are sometimes composed of a little pier or column supporting a circular or polygonal table (2). But those examples are rare, for most of these objects were destroyed, when in the last (18th) century men had the sad idea of ornamenting the chapels of our churches by woodwork painted white and gold, as done then for boudoirs.

Note 1.p.372. Diss. sur les princ. aut. des égl. Chap.25. 1688.

Note 1.p.373. Latin note.

CRENEAU. Crenelle. Embrasure. Slot.

By the word "cheneau" (crenelle) is now only designated the opening made in a parapet to permit the defenders of the walls to see the assailants and to launch projectiles. But in the middle ages by this word was understood every opening made at the top of a tower or a curtain, covered or uncovered, and which served for defense. We resume the name employed during

[illegible]

the middle ages, and we shall speak of battlements covered or uncovered, open or closed by shutters. Let us first state that the solid intervals between the openings are merlons, for there are no openings without merlons, just as there are no windows without piers.

Yet it is certain that in the middle ages the name was given indifferently to openings left between the merlons or to the merlons themselves. (Old French poem).<sup>1</sup>

Note 1. p. 374. Roman de Renart. Verse 22,579 et seq.

"Crenelle" is here evidently the merlon, for one cannot lean against the opening. However that may be, and since we take as much as possible the names generally adopted, it is understood that for us the crenelle is the opening and merlon designates the solid between them.

The dimensions of battlements being given by the height of a man, those dimensions vary little; the merlons are always nearly 6.6 ft. in height, to be able to completely protect the defenders; the sills of the crenelles are 3.3 ft. from the floor of the gallery, and their width varies from 3.3 to 2.3 ft. As for the merlons, they are very variable; we shall see why.

The crenelles crowning Gallo-Roman fortifications are generally pierced in parapets of great thickness, about 1.6 ft., built of rubble and brick, crowned by a coping slab forming a projection all around the merlon as indicated in Fig. 1. The merlons then only have a width sufficient to conceal a single man. These arrangements were determined by the system of defense of that epoch. It does not appear that the Romans employed the hand crossbow, they had archers and slingers, and each defender being equipped with one of these arms had his merlon for placing himself under cover, while he prepared to shoot. It was then natural to multiply merlons and crenelles as much as possible. The ancient walls of the city of Pompeii, built under the republic, and which are more Greek than Roman, present battlements where each merlon is furnished with a stone cross wall to protect the archer from arrows shot obliquely. Thus each archer possessed his little cell pierced by a crenelle. (1 bis). This system of battlements does not appear to have been followed by the Romans under the empire; they were satisfied with the battlements sketched in Fig. 1. Until about



the end of the 11 th century, it does not appear that sensible modifications were made in those Roman battlements. At that epoch expeditions to the East made known means of defense and of attack relatively very much perfected. The Byzantines and consequently the Arabs possessed war machines that drew the admiration of western men at ~~the same time~~, that they cast terror into their ranks; the walls of their strong places were well equipped and well defended. Thus after the first crusades we see in the West the system of the upper defense of towers and of walls is entirely modified. Not only is changed the system of battlements, but it is combined with the system of movable machicolations known under the name of defensive galleries. (Art. Houdard). the merlons are made wider, the crenelles become larger, and between them in the middle of the merlons are made narrow openings (slots) for firing the hand crossbow; with great care are avoided those projecting slabs that crowned the antique merlons, for those projections facilitate scaling, or give a hold for the grappling hooks, that the assailants cast on the tops of the walls to overthrow the parapets. The oldest battlements known to us in France, built after the crusades, are those crowning the towers and curtains of the castle of Carcassonne (end of 11 th or beginning of 12 th centuries). They are intact; here is the detail. (2). Here holes are already pierced in the merlons for firing the crossbow; these are narrow slots, splayed inside in arched form. These merlons are thick, built at the angles of cut stone and dressed rubble. Openings of the defensive galleries are pierced at the level of the floor of the gallery, and also a little below the sills of the crenelles, the lower holes to receive struts to relieve the overhanging beams passed through the upper holes. (Art. Houdard). The defensive gallery being placed, its floor then found itself at the level of the sill of the crenelle, thus the merlons are sufficiently high to allow a man to pass upright through the crenelles, as by as many doorways, so as to post himself in the defensive gallery. In time of peace, the battlements of the curtains of the castle of Carcassonne were not covered, while those of the towers were at all times covered by permanent roofs. The plates of these roofs passed along on the tops of the merlons and formed lintels (Art. Tour). The towers always commanded



the curtains, but being placed in communication with their galleries by well ironed doors and stairs, the battlements were extended to protect men on these steps, as indicated in Fig. 3, taken from the defenses of the same castle of Carcassonne.

Oriental influence is singularly pronounced in the battlement of the 12th century still preserved on a part of the south transept of the cathedral of Beziers. One knows all the importance of Beziers acquired at that epoch; it was defended by powerful walls, whose colossal ruins still are to be seen. The cathedral was built at the summit of the city, and was provided with an enclosure, and was itself a veritable citadel. The south transept commanded the entire cloister, whose external walls had battlements. Then see how this transept itself had battlements, on two projecting buttresses that strengthened its two angles was erected a parapet pierced by flanking slots. Such is the plan (4) of this crenelated parapet. It is seen that the five slots are drawn so as to send divergent projectiles. In the interior these slots are splayed with arches like those of the castle of Carcassonne. Here (5) is the external appearance of this crenelated parapet, with the beautiful quasi-oriental cornice on which it rests. The internal floor is at the level A, and the projecting head of a gargoyle carrying the water from the gallery. From the floor of the gallery to the cornice B there is a height of 4.1 ft.; but it is necessary to know that this battlement so dominates the exterior, that the men placed behind it, although their heads were above the cornice B, were perfectly masked from the assailants placed below. The four slots C (see plan, Fig. 4) are very plunging, while that at D is not so, and indeed this slot could only serve to look outward and very far from the foot of the monument. The distance separating the floor of the gallery from the great lower cornice is necessary for the archers to be free from the projection of the cornice, which is sufficiently indicated by the section (6) made on the axis of one of the slots C of the plan. Between the two buttresses very certainly existed a parapet with crenelles, that is unfortunately destroyed. It should not be forgotten, that in the cathedral of Beziers, this crenelation is at the same time the ornamental cornice of the religious edifice, which explains



this richness of mouldings, this upper moulded coping, that is not found in the military structures of that epoch. In the 13<sup>th</sup> century the crenelles are evidently constructed after a formula given by experience. The merlons are 6.6 ft high by at least 5.6 to 10.8 ft at most wide, with 1.2 ft. thickness; the sill of the crenelles is 3.3 ft. from the floor of the gallery, and their width is 2.3 ft. At the middle of each merlon is pierced a slot. The system of defence is studied with minute care.

Assume (7); at A is the external face of the battlements, at a are the slots, that have an opening not over 2.8 to 3.2 ins. wide, at b are the holes for the defensive galleries pierced at equal distances, so that the sills resting on the b beams may be cut with equal lengths beforehand; at B is the plan of the crenelation with its slots, which have a splay of 15.7 to 17.7 ins. at C is the section of a crenelle, at D is the section of a slot, and at E is the internal face next the gallery. The sill of the slot is always placed in a course below the sill of the crenelles, and (see the section D through the slot) the bottom of its plunging slope reaches a course b below the holes for the defensive gallery, so that the defensive gallery being placed, the crossbow men can shoot on the asrailants below the floors of this gallery. The bottom of the slots is cut as indicated by the sketch G, so as to give more breadth for shooting without exposing the crossbow men. One sees that the details are combined with the greatest care, and the constructors rigorously observe the same methods with very small differences during the course of the 13<sup>th</sup> century. These are battlements and curtains uncovered in time of peace, and covered only in case of war by the roofs of the defensive galleries. (Art. Hurd).

As for the battlements of covered towers in the 13<sup>th</sup> century, with battlements beneath the roof, here is how they were arranged (8). The walls are 3.0 ft. thick, the crenelles have a sill A, so as to allow the defenders to see outside, these crenelles are furnished outside with two hinged shutters falling into rebates, like the upper parts of the ports of a war vessel, the lower shutter swings by means of horizontal pivots in two iron hooks, not closed, so that it will be easy to remove it in time of war, when the defensive galleries are fixed;



for then the defenders pass through the crenelles as through doorways to take position on the defensive galleries. The upper shutter is supported by two hinges C fixed in the rebate a and opposite each other, these shutters are permanent. If two shutters were placed outside these crenelles instead of one, that was to render more easy the removal of the lower shutter, that a man can remove from within, as we have found, again it is that in case of attack, the defensive galleries not being placed, to protect the defenders from projectiles shot upward from outside, which does not prevent them from having air and light by leaving the upper shutter partly open. Even if one only leaves the lower shutter partly open, he can shoot on t the man placed below the towers without exposing himself. This system of shutters is adopted for crenelles placed in the parapets of curtains beside the doorways in the towers giving entrance to the galleries.(9).

This precaution was necessary to protect perfectly the men, that <sup>waited</sup> ~~were~~ in the gallery, for one to open to them the door in a tower after making themselves known. Thus are constructed without exception all the battlements of the towers of the city of Carcassonne, which date from the end of the 13 th century. Yet on the curtains of the same fortress near gate Narbonne, and that are earlier than the defenses built under Philip the Bold, are seen battlements much stronger than those of the 13 th century. It is true that this part of the city was that before which one could organize a regular attack. T These last battlements are then higher and thicker than the ordinary battlements of the curtains, and their internal surfaces next the gallery are built with a batter as indicated in Fig. 10. Each crenelle, by reason of the great thickness of the merlons, has a thinner wall beneath it. Although not covered, they were equipped with lower swinging shutters. The inclination of the internal surface seems to us to be made to permit the defenders to better flank the curtain, always leaving to the battlements an extraordinary force of resistance. Yet these defenses are light, if we compare them to those crowning the keep of the castle of Coucy.(Arts. nonjon, Hourd).

At the beginning of the 14 th century, the system of battlements of towers and curtains was entirely modified anew, for the wooden defensive galleries, frequently burned by the besiegers, were substituted stone defensive galleries, frequently



i.e., machicolations, and instead of leaving battlements recessed, they were made to project beyond the face of the walls, at the ends of corbels or arches forming machicolations. One of the oldest examples of this mode of construction and one of the most curious, in that it employs both arches and corbels to support the battlements and form a series of machicolations, is seen in the western facade of the cathedrad of Beziers, fo fortified in the 12 th century, as we stated above, repaired, partly rebuilt and fortified at the beginning of the 14 th c century. (Art. Machicoulis).

When making the crenelated parapets overhang the external walls, the constructors of the 14 th century gave the mouldings of the crenelles a new form intended to better protect t the defenders. It must be stated that the crenelles only served to cast stones on the assailants, the crossbow men or archers placed themselves behind the merlons, and discharged their arrows or bolts through the long slots. Now about the middle of the 14 th century, the armed besiegers were accompanied by very numerous bands of archers and crossbow men, and when the ramparts were attacked by mining, or it was desired to scale them, they covered the battlements with projectiles, to prevent the besieged from showing themselves. The old crenelles with their sides returned at right angles caused arrows to deviate, when they even wounded the defenders concealed behind the merlons. To avoid that inconvenience, the architects gave the crenelles pronounced external splays, and moulded these splays to prevent rebounds.

Fig. 11 explains the details of the defense; A is the section of the sill of the crenelle, at B is seen the lower moulding, and at C the upper round, which stops the arrows and bolts, preventing them from penetrating behind the parapet by rebounding. The defenses established in the 14 th century before t the western facade of the cathedral of Beziers form a moulded crenelation, moulded according to this system.

We indicate in Fig. 12 the external face of the crenelated parapet, which is placed on an arch in front of corbels forming four broad machicolations that open over the central rose window.

Fig. 13 presents the section of this battlement; the arch is at A, the machicolaions at B, with their corbels at C, and t



the projections D, designed to prevent arrows from ascending through the holes of the machicolations by rebounding, the section is made through the sill to the middle of the crenelle.

Fig. 14 reproduces the appearance of merlons from the interior, with the slots richly moulded at top. The crenelated parapet is here entirely independent of the corbels, that form machicolations, as shown by the section in Fig. 13 and the external perspective.

Since then the crenelles in defenses built with care, were furnished with these mouldings intended to prevent rebounds. Only it frequently occurred in the 15<sup>th</sup> century, that the mouldings with their splays could extend around the merlons, as indicated by Fig. 15. Sometimes at the end of the 15<sup>th</sup> and the beginning of the 16<sup>th</sup> centuries (for battlements persisted long after the invention of cannon), the merlons were decorated by sculptures, shields of arms, and medallions, as on the tower of gens d'armes at Caen and on some castles of the epoch of transition. Still when the use of cannon became general, men sought to modify the battlements so as to resist the new projectiles and to allow crossbow men to use them with advantage. It is not in the French feudal castles that must be sought these improvements. The French nobility long protested against the use of gunpowder, it yielded only very late to that new force, while on the contrary the free cities profited by it with enthusiasm. In the North, Switzerland, the old German cities, it is necessary to study these improvements introduced in the details of fortification while the use of artillery became more general.

One still sees at Basle a battlement on the advanced work of gate S. Paul, from the beginning of the 14<sup>th</sup> century, that has retained its slots arranged for crossbow men. This battlement is supported on false machicolations, that are merely a decoration there (16). The merlons are very thick and are pierced by wide slots fitted with stone cylinders rotating about two vertical pivots, so as to entirely close the slot while the soldier loads his arm.

At A is traced the plan of the merlon; at B the stone cylinder of the slot is turned to permit shooting, at C being so as to mask the opening. These merlons are otherwise very narrow, and are equipped with mouldings to prevent balls from rebound-

[illegible][illegible]

rebounding. There exist embrasures of this sort in the fortifications of Nuremberg preceding those erected by Albert Dürer. (Art. Embrasure). One also sees on the curtains connecting the great circular bastions built by that skilful artist around the same city, battlements arranged for cannon and for crossbow men, that meet being mentioned here, they are pierced in a very thick parapet, the slots are composed of a round hole with the sight above, the embrasures are fitted with pivoted shutters pierced by a hole for sighting before unmasking the muzzle of the gun.(17); the gallery is entirely covered by a shed roof. Several curtains of Nuremberg are equipped with wooden battlements placed above the parapets and pierced by embrasures for guns, as indicated in fig. 18. Evidently these wooden battlements, that recall the defensive galleries of the middle ages, were foreseen in the construction of the curtains, for the rounded glacis in which are pierced the embrasures are equipped with stone corbels intended to support these battlements in half timber work.

At the beginning of the 16th century were often seen curtains and ramparts reserved for great cannon, while the battlements for the crossbow men were pierced in the parapets below the crowns of these great works. These lower crenelated parapets then take the name of advanced work.(Art. Architecture Militaire).

The towers commanding the walls of Nuremberg, erected by Albert Dürer, are crowned by wooden battlements with shutters designed to protect the artillerists that served the guns of small calibre mounted on the upper platform. (Art. Tour). At the top of the watch tower of the castle of the same city is still seen a complete wooden battlement under the roof, with shutters rising inside.

Here (19) is a perspective view of one of these crenelles from the interior. At A a geometrical section shows the shutter raised with its hook. In France we are not so good in preserving, we have destroyed all those upper works in wood of our fortifications of the end of the middle ages. Ten years since at Langres were found some remains of the parapets in half timber work from the beginning of the 16th century, which have many relations to what we give here; but Langres having suffered a complete restoration, those old wooden galler-



galleries have disappeared to give place to parapets as high as the waist, with the regular sill coping slab.

#### CRETE. Cresting.

This name is given to the ornamental crowning of the roof. It was said that a roof in the middle ages, that it was crested, when its roof was crowned by a cresting of stone, terra cotta or metal.

During the Romanesque period, the roofs formed a very obtuse angle at the top conformably to the antique method. If the edifice had a tunnel vault, the covering of stone slabs or tiles was placed directly on the extrados of the vault, and a stone cresting covered the junction of the two slopes of the roof; this cresting was often decorated by openings, as may still be seen in most edifices of Auvergne. Even later (in the 12th century) perforated stone crestings were placed on the top of carpentry. Several reasons were the motive for the use of this sort of crowning. At first most carpentry was without ridge-beams and purlins, it comprised only a series of spaced rafters; it was then necessary to give a bearing to these rafters not connected together, by means of a load placed on their upper ends. It was also necessary to cover the last tiles by crestings, that were heavy enough to not be overturned by the force of the wind, and wide enough to prevent rain or snow from passing between the two slopes of tiles.

Everyone can see how on thatched roofs the peasants make a wide cresting of mud, in which they set grasses to retain the earth and prevent it from dissolving in rain.(1). The origin of crestings on roofs is found in this naive procedure.

On the coverings of edifices covered by tunnel vaults in Auvergne and the southern provinces of France, may yet be seen perforated stone crestings, which are very elegant. Here are (2) several models; these crestings are placed directly on the vault as indicated at A. At the top of the apsidal chapels of Notre-Dame-du-Port at Clermont, there exist terminations by crestings perforated in slabs, that start from the top of the cone formed by the stone slab covering of those chapels and rest against the wall of the side aisle.(3). In the provinces where tiles were generally employed for coverings, as for example in Burgundy, the crestings of roofs are composed



of a series of terra cotta crestings more or less decorated. (Arts. Haitiere, Tuile).

It is only on roofs covering vaults that were placed stone crestings; sometimes (especially during the pointed period) are seen crests carved on the tops of buttresses crowned by gables. Examples of these crests are found crowning the tops of the buttresses of the nave of the church of Notre Dame of Pijon (4). (Beginning of the 13 th century). There animals are combined with foliage, irregularly arranged. later during the 14 th and 15 th centuries, this sort of cresting consists of regular ornaments terminated by leaves.(5).

On carpentry covered by slates or metal were nearly always set crestings of lead after the 12 th century. The presence of these lead crestings was even motivated by the combination itself of the carpentry, which as we have just stated, consisted of rafters not connected together by ridge beams and purlins. The weight of the lead cresting placed at the tops of these rafters ensured their stability. Of crestings of lead on edifices before the 15 th century remains no trace; their presence can only be proved by reliefs, vignettes of manuscripts, and on shrines made in the form of little churches. To these objects of goldsmith's work it is necessary today to go to seek models of crestings in metal of the 12 th, 13 th and 14 th centuries, and those models are numerous. However, if one desires to use these goldsmith's crestings to apply them to monuments, account must be taken of the difference in scale, of the design to be modified in consequence. Some cresting of a shrine with a height of 2.0 to 2.4 ins, that produces a good effect, would become heavy and massive if one were pleased to increase it to 3.3 ft. in height. Experience alone can indicate the dimensions and proportions, that must be given to decorations outlined against the sky. Some ornament that seems well composed and proportioned in the studio is ungraceful heavy or confused, placed at the height of 98.0 ft. and detached in outline against the sky. For example, in that position it occurs that the delicate parts are devoured by the light, and on the contrary the solid parts are made heavy by losing their details. Broad designs, well accented, easy to seize and simply modeled, are those that produce the most satisfactory effect. Besides, for this sort of decorations to be

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understood, it is necessary for the same design to be repeated a great number of times. Then it is necessary in composing these perforated crestings to think of the extent to be occupied, the greater or less development affecting their composition. If the cresting be developed only for a length of some yards, it is necessary to choose, for balustrades, a close design in which the ornaments approach the vertical; on the contrary, if the cresting occupies a long ridge, it will be necessary to broaden the composition of the design.

Crestings of metal that exist on roofs covered with lead or slates were absolutely similar in the 14th century (so far as can be judged by the examination of reliefs) in style, and those crowning the shrines of that epoch; they appear to have assumed in dimensions the richness of great importance about the end of that century. It is useless to insist on the composition of the designs, that conform to the perfect taste of that time. We give (6) one of those crestings.

About the middle of the 13th century, metal crestings are transformed like all monumental ornamentation. Men abandoned the last traditions of designs brought from the East to adopt the native flora.(7). These lead crestings were generally pretty high, and also proportioned to the dimensions of the roofs; for a roof 39.4 ft. high the cresting should not be less than 3.3 ft. above the ridge. Iron frames were necessary to support the lead hammered sheets, that composed the cresting. These frames, as we have previously stated, fixed in V form on strips connecting the ends of the rafters, thus maintained these rafters in their horizontal planes and prevented the warping of the carpentry. Fig. 7 gives the iron framework of the preceding cresting. This framework being fixed, the ornaments in two shells beaten out by the hammer, were soldered together, after taking care to lay the coverings of the ridge on the strips A A. These procedures are still employed today. It was always necessary to compose these designs so as to permit a combination of the iron framework both simple and solid, if this framework failed, the lead cresting was left to its own weight, and did not delay to collapse. Crestings preceding the 15th century probably did not last long; it must be believed that the frameworks intended to maintain them were insufficient or fixed with little care. Struck by the inconvenien-



inconveniences connected with the system adopted after the 12 th century, the architects of the 15 th century composed all their crestings like balustrades, i.e., with a horizontal iron rail serving to crown the selected design. Thus were composed the crestings of the roof of the S. Chapelle of Paris repaired under Charles VII, and the ridge of the tower S. Romain belonging to the cathedral of Rouen (8); several of those of the old abbey of S. Ouen of the same city, that of the chateau of Meillant, etc. The latter compositions of crestings form actual lattices of wrought iron covered with ornaments of hammered or cast lead; but these designs are far from having the breadth and firmness required by decorations placed at a great height and outlined against the sky; they are thin and with details at too small a scale, lost at the distance at which one can see them. The crestings of that epoch are often decorated by heraldic arms or monograms, and if they occupy great length, at certain distances the ends of principals extending above the rail contribute to their stability. The cresting of the S. Chapelle at Paris is composed thus of bays comprising three great fleurs-de-lis between pinnacles covered with lead. There exists at the Imperial Library a drawing of this cresting. In our opinion, crestings crowned by a horizontal railing and in great part composed of straight lines are far from producing the effect to be sought in this kind of ornaments, which require a certain freedom in drawing forms derived from plants; one would think <sup>of</sup> a balustrade placed on top of a ridge.

The epoch of the Renaissance produced crestings of pretty design; some of them still exist; those of the cathedral of Clermont and those of the church of S. Wulfrand of Abbeville may be cited among the most beautiful and most complete. We possess in our portfolios a drawing of a beautiful cresting of that epoch of the Renaissance, that we think came from the chateau of Blois. The drawing dates from the beginning of the 17 th century; we reproduce it here (9). It consists of a series of Fs and balusters connected by cords; above the upper horizontal railing is a crowning composed of fleurs-de-lis and scrolls; four bays of Fs are comprised between pilasters terminated by spindles. A very rich coping serves as base for this cresting and covers the slates.



Men crowned by lead crestings the slate roofs of public edifices and those of houses even toward the end of the reign of Louis XIII. Dating from the reign of Louis XIV, they avoided giving importance to roofs and even sought to disguise them; consequently there was no longer any reason to ornament what one pretended to conceal. The lead work that crowns the roof of the chapel of Versailles is one of the last made with art. At the beginning of the 18<sup>th</sup> century, that beautiful industry of wrought and cast lead work was lost, and men scarcely knew how to solder at the end of the last (18<sup>th</sup>) century. (Art. Plomberie).

#### CROCKET. Crocket. Volute.

The name given today to these ornaments terminated by bunches of leaves or by rolled buds, so frequently employed in the monumental sculpture of the middle ages after the 12<sup>th</sup> century. Crockets are seen in friezes, and capitals, on the rakes of gables or gablets, in the hollows of archivolts between little columns combined in clusters. The 13<sup>th</sup> century especially adopted this ornament; it used this with some skill. In Art. Sculpture we have tried to explain the origins of most of the sculptured ornaments of the architecture of the middle ages; here we shall content ourselves with making known to our readers the different transformations of the crocket from the moment, that it takes place in decoration until the moment, when it entirely disappears from architecture.

We already find the germ of the crocket in the upper cornice of the nave of the church of Vezelay, i.e., in the first years of the 12<sup>th</sup> century. (Art. Corniche, Fig. 4). The internal capitals of the nave of the same church also show us in place of the antique volute leaves recurved on themselves, that already are actual crockets (Art. Chapiteau, Fig. 8). Yet it is in Ile-de-France and on the banks of the Oise, that the crocket assumes an important place in ornamentation from the middle of the 12<sup>th</sup> century. The first crockets appearing beneath the crowning slabs of the cornices already decorate certain churches built from 1150 to 1160. They are small with heads composed of three recurved leaflets quite similar to the cotyledons of the young plant. The stem from which these leaves spring is wide and swelled at base, so as to attach itself



to the moulding serving as base of the ornament.(1). About 1160 the crocket appears well characterized in the capitals; the choir of Notre Dame of Paris, erected at that epoch, is surrounded by cylindrical piers whose capitals no longer have anything of Romanesque sculpture. There are leaves starting from buds, scarcely developed, and at the angles are crockets with broad stems, powerful, with heads composed of leaflets recurved on themselves, plump and modeled with charming flexibility (1 bis). These leaflets soon give place to leaves; the head of the crocket develops relatively to the stalk; that is divided by longitudinal angles like the stem of celery. If the crockets are placed in the hollow of an archivolt, it frequently occurs that the base of the angular stem is accompanied by a leaf with its stipules well developed and adhering to this stem (2); which imparts grace and particular firmness to this sort of ornamentation.

At the end of the 12th century, the crockets on capitals often take the important place, they represent the angles of the abacus; they project beyond the middle portion of the bell; they are divided into separate leaflets, bend and coil like a bud commencing to develop. It is evident that sculptors have abandoned the last traditions of antique sculpture, and that they are inspired by plants, whose development they observe with minute care, as well as the charm of appearance, yet without restricting themselves to a servile imitation.

We give (3) several of these crockets already developed in buds, from the end of the 12th century; A comes from the sacristy of the church of Vezelay; B is from the choir of the same church; C is from the portal of the church of Montreale; D from the choir of the church of Eu, E from the choir of the cathedral of Soissons. All these crockets adhere to the capitals, and it is only after that epoch that this ornament is found around the bells, almost without exception. When these piers are composed of clusters of columns leaving at intervals a few inches between them, the head of the crocket is frequently placed between the capitals, and has two stems; this is a skilful means of avoiding disagreeable intersections, and to not interrupt the band of sculptures presented by these capitals.

Here (3 bis) is an example of these crockets with double stems taken from the piers of the church of Eu.(Art. Chapiteau).



At the origin of its development the crocket presents the greatest variety in the composition of the heads and the decoration of the stems. One frequently sees in edifices that date from the end of the 12 th century and the beginning of the 13 th centuries crockets on capitals or in archivolts terminated by human heads, their stalks are terminated by leaves or animals. The porch of the church of Notre-Dame-de-la-Coulure at Mans is covered by an archivolt that presents a beautiful collection of this sort of crockets (4). It often occurs that an animal sometimes replaces this ornament, while retaining its characteristic outline.(5). Thus one sees crockets, whose heads reproduce the form of a flower (6).

About 1220 the crocket no longer presents a developed bunch of leaves, but always ~~scrolled~~ on themselves; the imitation of nature is more exact, the mass of the head is less rounded and enlarged at the expense of the stalk. The archivolts of the great openings of the towers of the cathedral of Paris present perhaps the most beautiful examples of this sort of sculptured decoration.(7, 7 bis). In Ile-de-France from 1220 to 1230, the architect abuses the crocket; he places it everywhere, and especially uses it to break straight lines detached against the sky, like the angles of spires, the external piers of towers, as one can see at Notre Dame of Paris and on the tower of the cathedral of Senlis. In this case the crockets are placed at a great height, they are composed of a simple head terminating a stem with a single midrib (7 ter). It is understood that each crocket is comprised in the height of a course. About 1230 this vegetation in stone seems to expand, as if time acted on these monumental plants as it acts on living plants.

The archivolts of the entrance of the chapter hall of the cathedral of Noyon are decorated by a double row of leaf crockets, which are perhaps the most developed of that epoch and the richest in sculpture. (8).<sup>1</sup>

Noet 1.p.408. This beautiful hall has just been restored by the care of the Commission of Historical Monuments dependant on the ministry of State, and under the direction of M. Verdier. One can say that this magnificent example of the architecture of the 13 th century has been saved from ruin.

The school of Burgundian sculpture is distinguished among a

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all others in the composition of the crockets. This school had given from the Romanesque epoch to sculptured monumental decoration an amplitude, boldness and power, a warmth of modeling, which in the 13 th century, when sculpture acquired no more strength in the imitation of the local flora, must produce the most brilliant compositions. Thus the crockets sculptured on the monuments that date from the middle of that century present very remarkable exuberance of vegetation. (9, 9 b bis).<sup>1</sup> The Norman and Anglo-Norman school perhaps excels the Burgundian school; it exaggerates the ornamentation of the crocket, as it exaggerates all details of Gothic architecture arrived at its development; but less scrupulous in its imitation of the flora, it knows not how to retain in the sculpture of ornament that strength and variety, which charms in Burgundian sculpture. All Anglo-Norman crockets of the middle of the 13 th century resemble each other in spite of the efforts of sculptors to give give them relief, and surprising modeling, they seem confused, and at a distance produce no effect, because of the defect of masses of heads too much recurved and the extreme smallness of the stems. We give (9 ter) one of these AngloNorman crockets taken from the cathedral of Lincoln.

Note 1.p.409. From the facades of the church of Vezelay and of S. Pere-sous-Vezelay.

Yet the heads of crockets gradually tend to become modified; those leaves and recurves, enveloped as they were at first in a uniform mass, straighten and grow, so to speak, extending on the bells of the capitals, and beneath the mouldings of friezes. At the S. Chapelle of Paris (1240 to 1245), are already seen heads of crockets that have become groups of leaves, mingling and running beneath the bells; petioles leave the ribs and the stems (10), while in the great crowning friezes the crockets still retain their monumental and symmetrical character until the 14 th century (11).<sup>1</sup> On the rakes of gables crowning the windows, from the middle of the 13 th century, along the gables of edifices, were placed crockets inserted in grooves in the copings forming the covering. (12). It is certain that these stone sculptures inserted along the copings of the gables and maintained at certain distances by T-anchors, as indicated in Fig. 12 bis, would not have a very long duration;<sup>1</sup> but they could also be easily replaced in case of accident or



of deterioration caused by time. It is unnecessary to see in the crockets of the rakes of gables more than a decoration analogous to those antefixas or open crownings, that the Greeks also set in grooves in the facias of pediments. We have frequently heard blame to the architects of the middle ages for this attached ornamentation because of its fragility; it is necessary to be just and not approve that of the Greeks. The Gothic architecture daily became more elegant and refined; the rounded heads of the crockets were regularly spaced along these inclined planes but soon appear heavy, however delicate they are. These ornaments are recurved on themselves, falling on their stems, appose the ascending lines of the gables. In 1260 men already renounced their use, and they were replaced by bent leaves, ascending the inclined openings of gables, rising at certain distances to form an indented line. It may be admitted that this sort of crockets was first applied to the gables of the portal of Rheims, and to that of the red doorway of the cathedral of Paris, structures erected from 1257 to 1270.(13). Crockets with round heads remain on the little gablets of pinnacles, arches and shrines, because it would not have been possible to sculpture ascending leaves of very small dimensions. It is understood, that these little crockets are of very simple form; we give here (14) several examples at half full size.

Note 1.p.411. From the south tower of the facade of the cathedral of Amiens.

Note 1.p.412. But one still finds a good number of crockets of the 13 th century attached to the copings of gables.

At the cathedral of Beauvais, we see crockets on the angles of the pinnacles of the choir that take a particular form, in these crockets were sculptured about 1260, they recall certain water leaves, and are distinguished by their extreme simplicity (15). In general, crockets are like all sculptured ornaments of Gothic architecture, very projecting and developed when the nature of the material permits, meagre and projecting little, when the stone employed is friable.

During the 14 th century, crockets of the openings of gables or gablets take more amplitude, they conform in execution to the taste of the sculpture of that epoch; they become distorted or rumped; they are less refined than those of the preced-



preceding century, but represent leaves rolled and massed on themselves (16). About the beginning of that century, they disappear from all cornices and capitals. When these crockets are of small dimensions, as for example along the angles of pinnacles, they are near each other, and frequently imitate the form of water leaves or of seaweeds. (17).

On the contrary in the 15<sup>th</sup> century, the crockets of the copings of gables take a considerable development, are farther apart and are connected by leaves running along the copings; they adopt the twisted forms of the sculpture of that epoch. But particularly in Ile-de-France, their execution is broad, full of strength, freedom and flexibility, the leaves composing them are leaves of the thistle, granadilla, curly cabbage, parsley and geranium. (18). This kind of ornament belongs to the Gothic epoch, it is the necessary complement of the ascending forms of that architecture, it accompanies its rigid lines and destroys their dryness, either when these lines are outlined against the sky or are detached from the bare wall, it gives scale and grandeur to edifices, producing effects of vivid and picturesque shadows and lights. When the Renaissance returned to what it believed to be the imitation of the antique, the crocket no longer finds application in architecture. During the period of transition between Gothic and French Renaissance, i.e., between 1480 and 1520, one again finds the existence of rampant crockets. Some of them are very beautiful and finely wrought (19); such are those of the mansions of Cluny and de Tremoille, of the church of S. Germain-l'Auxerrois, the rood screen of Alby, the western facade of the cathedral of Troyes, of the church of Toul, etc. (For the general arrangement of crockets, see Arts. Chapiteau, Corniche, Fleuron, Gable, Pignon and Pinnacle).

Our readers will perhaps find, that we have given to a detail of ornament an exaggerated importance, but they will do well to consider, that in this the sculptors of that epoch, that particularly occupies us, have been creators, they have gone nowhere to seek models in preceding arts; nothing is like it in the Roman sculpture of which they possessed fragments, nor in the oriental sculpture, that they themselves saw and studied. If we have given a great number of examples of these crockets, it is because that we have always heard expressed by architects studying Gothic architecture the diffi-



difficulty, that they found, not only in composing and having executed this ornament, so simple in appearance but of such prominent character, and even in drawing the crockets that they had before their eyes. Further in a style of architecture, there is no insignificant detail, the smallest moulding, the most modest ornament, have an appearance participating in the entirety, an aspect that must be studied and known.

#### CROIX. Cross. Crucifix.

During the middle ages a cross of stone or metal was placed at the top of religious edifices, on the roads, at entrances of cities and in cemeteries. It is well to state first, that the image of Christ was not suspended on the cross until about the 6<sup>th</sup> or 7<sup>th</sup> centuries, until then the instrument of punishment, that became under Constantine the symbolic sign of the Christians, was represented plain. In the catacombs of Rome exist representations of the cross ornamented by gems, from the two arms are suspended lamps. But we do not think that there exists a single painted or sculptured representation of the crucifix earlier than the 6<sup>th</sup> century, and again from that epoch until the 12<sup>th</sup> century, these images are very rare. (Art. Crucifix). We only have to occupy ourselves in this Article with crosses belonging to the architecture, which are attached to the monuments, or that themselves form little isolated monuments.

#### CROIX ATTACHEES AUX EDIFICES RELIGIEUX.

##### Crosses attached to Religious Edifices.

These crosses are of three kinds, crosses sculptured in stone, crosses of metal, and painted crosses.

The most ancient sculptured crosses nearly always have four equal arms; they decorate the tops of gables, tympanums of doorways of churches, fronts of buttresses or piers; they are also sometimes found on capitals and the keystones of vaults.

The primitive cathedral church of Peauvais, known under the name of "Basse-oeuvre" (lower work) already existed in the year 990. That edifice appears to date in the 8<sup>th</sup> century and presents on its western gable a stone cross inscribed in the masonry, and ornamented by little cubical stones. That cross we give (1), and it is chamfered at the edges and has a foot terminating in a point. The badge of the church of the priory

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## THE CROSS IN THE MIDDLE AGES.

During the middle ages the cross was not only a symbol of  
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of Montmille, erected after the beginning of the 11 th century near Beauvais, is ornamented by an inlaid cross, that recalls by its form that of the Basse-œuvre; but <sup>to</sup> the cross of Montmille is already attached a figure of Christ with a halo. (2). <sup>1</sup>

Note 1.p.419. See *Archæol. de l'ancien Beauvoisis*, by Dr. Koilliez.

From the 11 th century, chiefly in Berry, Nivernais and Auvergne are found crosses, no longer inlaid in the tympanums of the gables of churches, but crowning their apexes. The western facade of the church of Ebreuil, that dates from that epoch, still shows behind the tower of the 12 th century a crowning cross of stone, and of curious form. Here (3) at A is the front side, at B is the back and at C the edge. There is reason to admit that these crosses, detached against the sky at the tops of gables, were very common on the religious edifices of the Romanesque period; but the fragility of these thin perforated slabs, exposed to storms, must have quickly caused their destruction.

In reliefs of the 11 th and 12 th centuries, where the gables of churches are represented, the summits of towers are always terminated by crosses, most frequently with equal arms, placed on a ball or on a column rising from an ornament. The canopy that protects the seated Virgin of the tympanum of the portal of S. Anne at Notre Dame of Paris (12 th century) bears a cross of that kind at the base of its dome (4). At the end of the 12 th century the crosses serving as terminations of gables always have the foot longer than the other three arms, or they are supported by a sort of pedestal, that isolates them from the gable; such is the curious cross found in the excavations made by M. Millet in the church of Notre Dame of Melun, when he undertook the restoration of that church. M. Millet thinks with reason, that this cross (4 bis) was placed on the gable of the western facade; we believe that it belongs to the end of the 12 th century. The church of Montreale near Avallon, which dates from that epoch, still possesses on its four gables beautiful crosses of varied forms, whose graceful outlines terminate perfectly on the exterior of the simple structure of that church. We give (5) one of those crosses cut in great slabs of hard limestone from Contarnoux. That is only



5.3 ins. thick at its base as indicated by the side elevation A.; the foot is sunk into the stone crowning the gable, and the centre of the cross is perforated.

During the 13<sup>th</sup> century statues were in honor, and whenever they could, the architects terminated the gables by statues rather than by crosses; yet the gables of the transepts of S. Urbain of Troyes have still retained in place the remains of the crosses of the end of the 13<sup>th</sup> century, very rich and of great dimensions. We reproduce (6) one of them, that is cut in hard stone from Tonnerre. This cross is composed of six pieces: a foot A, a ring B in two courses, a vertical C, a cross-piece D, and the upper arm E. At G is traced the plan of the cross at the level A, and at K is seen in section how the double ring encloses the two ends A and C of the foot of the vertical. Besides this double ring, whose two parts are made solid by six little copper cramps set in lead, there exists at I a copper pin; another copper dowel maintains the upper arm, the cross-piece and the stem. All the joints and dowels are cast with lead with great care. Two heads of bishops ornament the centre of the cross, and these two heads with the corbels and supports contribute in giving a bearing for the cross-piece on the stem. As always in the architecture of that epoch, the decoration is there the result of the construction, and this decoration is not at all bad. We have said that many times, and we repeat it again, for it is necessary to insist on it; if the truth appears or is spoken only once, no person has seen or understood it; it is necessary to repeat it, when persons treat it as trifling, then they have understood it.

During the 15<sup>th</sup> century, gables are frequently terminated by crosses; but these lose their monumental character suited to these ornaments placed at a great height, and they are covered with details like the crosses of cemeteries or of roads, made to be seen near at hand.

But the gables of country churches, where sculpture could not be lavished, were terminated by stone crosses as in the preceding centuries. These crosses are simple, usually supported by a short cylindrical column, terminated by a ring forming a capital. Such is the little cross of the church of S. Thomas. (7). The coping moulding covering the gable proj-

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projects to form a foot and to give breadth at the base.

It is known how the order of Cîteaux has opposed, in the churches that it built during the 12 th and the beginning of the 13 th centuries, to the sculptures lavished in the edifices of the order of Cluny. (Art. Architecture Monastique). The tympanums of the portals of the churches of the order founded by S. Bernard are usually decorated only by a simple cross in relief. We give (8) that still seen above the lintel of the doorway of the church of Pontigny, and which dates from the end of the 12 th century; its four arms are of equal length.

Also frequently in the interiors of churches on the piers, and even on the exterior, on the faces of the buttresses, were sculptured in the Romanesque period crosses with equal arms. Most of these crosses (at least those in the interior) were crosses of consecration. One of these crosses is to be seen today on a buttress of the church of S. Palais. Although that dates from the 13 th century, the cross (9) certainly belonged to an edifice of the 11 th or 12 th century, and it has all the characteristics of a cross of consecration. There still exists on the facade of the church of S. Giers-la-Lande three engraved and pointed crosses, one on the keystone of the doorway, and the two others on the sides of the jambs. Here is one of these crosses; (10); they are only incised lines filled with black color.<sup>1</sup>

Note 1.p.426. This note was furnished to us by M. Aloux, architect at Bordeaux.

On the piers of the walls of the side aisles of churches of the 12 th, 13 th, 14 th and 15 th centuries, we have frequently discovered under the whitewash painted consecration crosses; here are several examples (11). The cross A seems to us to belong to the 13 th century; B to the 14 th and C to the 15 th centuries. In our engraving black indicates black; dark gray is reddish-brown; light gray is yellow ochre, and white is white; these are the colors generally employed.

It sometimes occurs that the consecration crosses of churches during the 13 th and 14 th centuries were borne by painted or carved figures of the apostles. In 1854 was discovered in the church of S. Hubert of Warville under the whitewash mural paintings, among which are seen apostles bearing the crosses

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of consecration. These figures are painted on the walls of the side aisles and choir; they are described and engraved in Vol. 20 of the *Statistique monumentale*, published by M. de Caumont. Everyone knows the statues of the apostles at the S. chapelle of the palace at Paris, which bear the consecration crosses. (Art. Apotre). On the piers forming the heads of the chapels of the cathedral of Troyes are noted square stone slabs overlaid, the angle down, on which are painted figures of apostles also bearing crosses of consecration.

During the middle ages iron crosses were always placed at the top of wooden towers covered with slates or lead, and even sometimes at the apexes of the stone pyramids, that terminated the towers of religious edifices. The iron crosses were surmounted by a cock or a simple vane. There exists a small number of those old metal crosses, often damaged by lightning or destroyed by time and the hand of man. Most were of rich design, gilded and of large dimensions. Their base consists of a ball or of a ring frequently representing a dragon, a symbol of the demon, or again the crown of leaves. Relics were usually deposited in the ball, that served as their base, or in the cock surmounting them. (Art. Coq). The system of connection of these terminal crosses merits being studied with care by constructors; for these iron articles placed at a great height, heavier at top than at base, were exposed to hurricanes and did not fail to break soon, to be deformed or wear their fastenings. If these crosses were fixed in stone, to avoid the vibration produced in the fastenings by the force of the wind on the body of the cross, it was necessary to proceed with extraordinary precautions. The principal stem was composed of three or five bars, one central and two or four braces. Assume the apex of a stone spire composed of courses (12). The hollow portion of the pyramid stops at R. The main bar of square iron C D passes through the solid courses of the top of the spire forming a terminal, and its lower end is fastened by a key at D. Two or four braces E, held by two bands I K, bent according to the profile of the crowning, abut against a stop on the rod at G; so that if the wind pushes the central bar to one side, its force is neutralized by the resistance opposed by the braces, the resistance resolved into a pressure at F or La As for the two branches of the cross,



they are connected by halving, as practised in modern ironwork, and which is very bad, but by means of a reinforced socket with a hole for a bolt or great rivet, as indicated in Fig. 12.

These minute details are not to be disdained; too frequently in our days their execution is left to a contractor, who in his turn refers them to a foreman, who trusts to the intelligence of a workman. An accident happens, one takes it to the architect, who transfers the fault to the contractor, who throws the blame on the foreman, that accuses the workman, who left the yard six months previously!

If the iron cross is placed on the top of the frame of a wooden spire, its stem has under the covering two, three or four branches, according to the degree of strength to be given to the cross and the resistance that must be opposed to the wind. The branches of the fork are nailed to the wood, and further have bands fixed hot, to strongly hold the ironwork. If the cross is of very great dimensions (a cross of a spire like that of Amiens or of Notre Dame of Paris cannot have less than 26.3 ft. in height), it is composed of a considerable number of pieces, that we can separate thus, (14); 1, the stem A (see Horizontal section P) with its reinforcement for receiving the crossbar, 2, the crossbar B; 3, the four square bars C, more or less decorated and maintained by means of rivets indicated in the detail C (these square bars are intended to prevent the crossbar from straining the joint and central bolt, and as a result to incline to one side or the other); 4, D the four branches with indents forming forked branches nailed and banded on the ends of the wooden principals; 5, E the three bands made as shown by the sketch E, with little keys, so as to be strongly fixed; 6, F the cap, and G the clips, 6, H the bolt holding the crossbar against the stem in its recess, in all 17 pieces of iron. At M is sketched the end of the stem and the cross, with the rod on which turns the weathercock, at l is forged an end of the crossbar. T The stem is independent and is only maintained in a vertical line by the four branches D fixed at the top of the principals. Such ironwork with a height of 13.1 or 16.4 ft. may retain the elasticity necessary to not be broken by a hurricane, for the four braces taking the place of forks always act inversely; if one is stressed by the effect of the wind by the means



of the stop I, the opposite reinforcement acts as a tie by the resistance opposed by the indents K. It is unnecessary to say that the timbers are covered by lead up to the cap F. If the cross attains greater dimensions (23.0 or 26.3 ft.), it is prudent to have double braces with double stops and doubled indents, to make the stem of two bars bolted and riveted together, placing the crossbar between them. Ironwork so combined could be enriched by means of scrolls and ornaments of hammered iron attached and riveted. The braces with their joints could be covered by leaves of plate cut and modeled, accompanied by branches of round iron, recurved and bearing at their ends flowers of cut plates.

Fig. 15 gives the idea of this sort of applied ornamentation.

On spires of ordinary dimensions, iron crosses do not need to be combined and fixed with this luxury of precautions. Some are so forged that the branches and vertical stem form only a single piece with its parts welded together. The little iron cross of the tower of Puybarban near Reole is so fabricated. Although that cross has been placed on a spire of the 17<sup>th</sup> century, it is of the end of the 13<sup>th</sup> or 14<sup>th</sup> centuries.<sup>1</sup> We present (16) the general drawing and the details. The fleurs-de-lis are doubled, i.e., are placed in two directions as indicated by the perspective sketch (16 bis) of one end of the cross. A little vane rotating on the upper arm here replaces the traditional cock. The cusps that ornament the central square are simple riveted to the sides of the square. In spite of its extreme simplicity, this cross does not fail to be of graceful form; and if we are accused of indulgence favoring the arts of the middle ages, we should not prefer to it the cast iron crosses, that are now placed at the tops of spires. That opinion is very probably not shared, since most old iron crosses, that have resisted the storms of the end of the last (18<sup>th</sup>) century, have been taken down and sold to the dealer in old iron in exchange for those models in cast iron, that one finds on the quays of Paris in company with stoves and garden seats. In Brittany and Normandy are still found some spire crosses of wrought iron, that date from the 15<sup>th</sup> and 16<sup>th</sup> centuries. Here (17) are some of the motives most commonly reproduced.

Note 1.p.431. H. Aloux, architect, took the trouble to draw this wrought iron cross.



## CROIX DE CHECINS ET DE LA CIMITIERE.

## crosses of Roads and of cemeteries.

At what epoch did men commence to erect crosses at cross roads, at the entrances of cities and villages and in Cemeteries? I cannot say. One can only state that this custom was very widely distributed from the first times of the middle ages. Among the monuments still standing, we know none that precede the end of the 12 th or beginning of the 13 th centuries. It is to be believed that many of these crosses earlier than the 13 th century, of stone or wood, were covered by a hood; for in a manuscript of that epoch is read this passage: (old french text).<sup>1</sup> thus there have existed coverings over the roadside crosses, since the priest Jehan does not wish them placed on those erected in his territory, so that over the cross there is nothing blessed or consecrated. This idea indeed seems to prevail during the 13 th century, for one finds no old traces of hoods or of shelters covering the roadside crosses at that epoch in the north of France.

Note 1.p.433. Additions aux Oeuvres de Rutebeuf; Lettre de Prestres-Jehans, published by Jupinol. Vol. II. p.464. There exists a beautiful cross of sandstone at the top of Rue S. Bertin at S. Omer; That cross was destroyed a few years since, and is said to have dated back to the 10 th century. (See the Abber de S. Bertin, by M. Henri de Laplane, part I, p. 118. S. Omer, 1854.

Further, there is reason to believe, that crosses were not protected by hoods except when they bore the Christ, or when they were made of perishable materials, or painted and gilded; for one still sees Romanesque crosses of cemeteries and cross roads, that certainly were not made to be placed under a shelter. The stone cross here given (18), and which is still placed in the cemetery of Baret near Barbezieux, is int too rude work for anyone ever to have had the idea of covering it. This cross appears to belong to the 11 th century.

The crosses at cross roads are usually placed on a base forming a sort of little altar with some steps before it. the crosses of cemeteries rise on steps more or less large, a table is placed before or around the column bearing the cross. In the cemetery of Mezy still exists a cross of this kind, whose column passes through the altar table supported by four figures of the evangelists backed by little columns (19). We give



at A a section through the axis of the column. The top of this stone cross no longer exists, the column is broken off at the level B. To complete it we give (19 bis) the fragments of a beautiful cross of the same epoch (about 1230), that are deposited under the porch of the church of Rougemont. On one side of this cross is attached the Christ, on the other in the sculptured medallion at the centre is carved a hand of blessing. The section of the stem is sketched at A, that of the arm at B. About the middle of the 13<sup>th</sup> century, crosses of roadsides or of cemeteries frequently presented the Christ attached to the front, and on the back the Holy Virgin carrying the Child; or again the statue of the Virgin is placed against the column beneath the cross ~~xx~~ <sup>and</sup> the crucifix is double. One sees at Four-heres near Troyes the remains of a charming cross of this kind, which was formerly placed at the head of the bridge. It rested on a pedestal and steps. To the column is attached a statue of the Holy Virgin 4.6 ft. high, it stands on a group of three little columns connected to the main column. From the capital that terminates the column rises the half length of an angel, so arranged that its wings and body form a canopy over the head of the statue (20). Formerly a stone crucifix about 5.9 ft. high surmounted the capital; the figure of Christ was sculptured on each face; one turned to the east and the other to the west, the ends of the arms of the cross were terminated by bunches of leaves. That crucifix is now destroyed, and the little monument exists only up to the upper capital. The Virgin looks toward the ground and smiles; her head is covered by a veil and by a fleury crown; Every year, during the harvest and vintage, the peasants attach bunches of wheat and grapes to the feet of the mother of the Saviour.<sup>1</sup>

From the base of the crucifix the column is composed of three stones, whose beds are marked at L. The horizontal section b below the Virgin gives the plan A. It is understood that the statue is cut in the same block of stone as the column against which it is placed.

Note 1. p. 434. We owe this drawing to M. Millet, diocesan architect of Troyes.

Most of these roadside crosses were erected to preserve the memory of a memorable fact or as a mark of separation. On the route followed by Philip the Bold from Paris to S. Denis, be



bearing on his shoulders the remains of the king S. Louis, we were erected at each station of the procession stone crosses, that passed for very beautiful works. Remains of them were still seen in 1792. they were very beautiful, of lias stone, and placed on high steps.

During the 14<sup>th</sup> and 15<sup>th</sup> centuries, to the road crosses was given great richness, the figures accompanying Christ were multiplied, while always retaining the primitive arrangements. In our provincial museums are still seen a quantity of remains of road crosses, they were multiplied infinitely, for the old ones were removed and new ones were erected daily; but it is rare today to find any that were not broken during the religious wars or at the end of the last (18<sup>th</sup>) century. Yet there exist some in the localities forgotten by the iconoclasts; they are of rude work, for the most beautiful were found near the great centres, and these were first to be destroyed, yet all these monuments of barbarous execution are copies or reminiscences of works, that passed as being remarkable, and from that point of view should be studied with care. Among those rude imitations, we can cite the cross of Belpech (21). The cross is carved and decorated by cross-flowers, and bears on one side Christ having the Virgin on his right and S. John at his left. At the bottom of the cross two little figures receive the blood of the Saviour in a chalice. Two heads above the arms of Christ personify the sun and moon. The back bears at the centre the Holy Virgin with the Child. Two angels hold the crown of the mother of God, on her right is S. John Baptist; at her left is S. James the Pilgrim. The capital bears four very stumpy figures with halos, among which is distinguished S. Andrew. Two escutcheons are seen between the figures. This monument dates from the end of the 14<sup>th</sup> century; it was entirely painted and covered by a hood, for it appears that at the end of the 14<sup>th</sup> century men returned to that custom of covering roadside crosses.

There is still seen on the place of Royat opposite the church a pretty cross of lava of the 15<sup>th</sup> century. We give a view of it (22). The figures of the 12 apostles are sculptured on the principal shaft between four small buttresses. An inscription giving the year 1481 is carved at the foot of the cross beside the Virgin. On the faces of the base in little niches



are noted 8 little figures, probably of prophets.

The roadside crosses, of cross roads and of cemeteries were not always cut in stone, marble or granite, they were constructed of wood, inserted in a stone base. It is unnecessary to state that these were destroyed long since; their existence can only be proved by the presence of these stone bases pierced by a square hole, that one still finds in the country and in cemeteries. There also existed crosses of bronze and of wrought iron. Those metal articles, particularly those of bronze, were melted at the end of the last (18 th) century, and we no longer possess a single example in France. The form of these bronze crosses differed from those given to crosses of stone or of wood; they were more slender, more detailed and richer, and they were frequently divided into several branches to support the figures. In the Album of Villard of Honnecourt is seen one of these crosses, whose upper part could only have been executed in cast copper.<sup>1</sup> It consists of a column, perhaps of stone, placed on steps. From the column rises the cross with Christ and two crosses fully detached, bearing the Virgin and S. John. If we take into account the conventional manner employed by Villard in his drawings, and we restore the sketch and proportions, we obtain Fig. 28, which gives a beautiful example of a stone cross from the ground to the level A, and of metal from A to the top, this cross belongs to the time when Villard lived, i.e., to the first half of the 13 th century. Save some rare exceptions, Villard was not an archaeologist and only filled his Album with drawings made from contemporary monuments. "In the 15 th century" says Courtalon, "there existed at the church of S. Remy of Troyes a numerous confraternity of the cross at the altar of that name. With the offerings made there, the members could erect in March of 1495, near the church of S. John in the grande Rue, a very beautiful monument in honor of the cross, that was called the Belle-Croix. (Beautiful cross)."<sup>2</sup>

Note 1.p.441. See Album de Villard de Honnecourt, architect of the 13 th century. p. 85. Pl. 14. Imp. Lib. 1858.

Note 2.p.441. The place occupied by that cross at Troyes still bears the name of Belle-Croix.

The description of this cross, that is found entire in the Voyage archæologique dans le département de l'Aube,<sup>3</sup> gives t



the idea of a monument of great importance. This cross was entirely of bronze, except the pedestal, and was decorated by numerous figures, among which were distinguished Satan and S. Simon the magician, that the people of Troyes called Simon Maquet. . At the feet of the Christ was seen the Magdalen embracing the foot and the stem of the cross, at each side were S. John and the Virgin; below were S. Louis, S. Loup, S. Louis and prophets, among whom was seen Mahomet. A memoir on this monument was drawn up in 1530 and reported by Grosley, which informs us that it was originally surmounted by a canopy or dome of masonry, borne by very high columns, "the whole very triumphant and full of paintings of gold and azure, furnished with images and other beautiful and appropriate works. That at this cross replaced one of hard stone decorated by images, that fell into ruin and decadence, was removed and transported to the cemetery of Hotel-Dieu-S. Esprit, and was then collected and erected close to the tomb of the noble man, Nicolas Boutiflart, during life a citizen of Troyes." On Wednesday, Dec. 5, 1584, a hurricane overthrew the dome on the cross, which was broken, though a great bar of iron traversed it from top to bottom. "The fall of the beautiful cross," adds M. Arnaud, "facilitated the examination of the relics that it enclosed; there was found in the head of the image of the Virgin, which was behind the crucifix, a small closed bronze box fastened by an iron wire." The following year, In 1585, the beautiful cross of Troyes was restored, but without the dome that covered it. This monument was melted in 1793; it furnished 942 lbs of bronze, its height was 36 ft.

Note 3.p.441. A curious work published by M. F. Arnaud, painter. Troyes. 1831.

We give (24) from an old drawing and stained glass of 1621, representing "the entry of king Henry the Great into his city of Troyes in 1595," the entire monument without the dome that covered it, of the form of which we have no graphical data.

In Brittany are still seen a great number of stone crosses from the 15 th and 16 th centuries. (See Voyage pittoresque dans l'ancienne France, by M. Nodier and Taylor.

CROSSE. Art. Crochet.

CROSSETTE. Horizontal end of a voussoir.



Stonecutters give this name to the ends of the voussoirs of an arch, that return horizontally to form a wall. During the middle ages these were not employed in the jointing of arches; they always had an extradados. (Arts. Appareil, Construction).

#### CROUPE. Hip Roof.

Signifies that a roof does not rest against a masonry gable. Circular or polygonal apses of churches are terminated by hip roofs. (Art. Charpente). In civil architecture, architects until the 16<sup>th</sup> century very rarely employed hip roofs; the buildings are covered by gable roofs closed by gables at their ends. This was an antique tradition that the middle ages had scrupulously retained, and it was very wise. The artists of the Renaissance, and particularly those of the 16<sup>th</sup> century; who pretended to return to the principles of antiquity commenced to place on edifices roofs terminated by hip roofs, and in our days as one on the facade of the Pantheon, for example, men have gone so far as to place hip roofs on pediments that are gables. It is difficult to carry farther the forgetting of the principles of the architecture of the Greeks and Romans. But in the history of our art, one finds during three centuries many other singular things.

#### CRUCIFIX. Crucifix.

Christ on the cross. In cathedral, abbey or parish churches, it was customary to place great crucifixes of wood or metal suspended over rood galleries or transverse beams, that indicated the entrance to the choir. There exists in the museum of Cluny a crucifix of the 12<sup>th</sup> century, as large as nature, which must have been made to be set above a beam. This figure is of chestnut wood; the nude parts are covered by painted parchment; the draperies, head and hands alone are without a covering. Du Breuil<sup>1</sup> relates that at the entrance of the choir of the cathedral of Paris, at the top of the gates of the rood screen rose "a great crucifix, that with its cross was in but one piece," and he adds, "that its foot was made in an arch of another single piece, which are two masterpieces of cutting and sculpture."

Note 1. p. 444. Theatre des antiquites de Paris, p. 13. 1622.

"In the primitive times," says M. Didron,<sup>1</sup> "was seen the c

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cross, but without the crucified deity. About the 6<sup>th</sup> century is a mention of a crucifix executed at Narbonne; but this is a strange fact and mentioned for its novelty. In the 10<sup>th</sup> century some crucifixes appear here and there; but the crucified One appears there with a mild and benevolent countenance; he is further clothed in a long robe with sleeves, that only permits the nude to be seen at the extremities of the arms and legs.<sup>2</sup> In the 11<sup>th</sup> and 12<sup>th</sup> centuries the robe is shorter, the sleeves disappear, and already the chest is sometimes uncovered, because the robe is only a sort of tunic.<sup>3</sup> In the 13<sup>th</sup> century the tunic is as short as possible; in the 14<sup>th</sup> it is only a piece of woolen or even of linen, wound around the loins, and thus until our days, Jesus on the cross has constantly been represented. At the same time that gloom is cast on the figure of the crucified, and that are impressed the physical sufferings of his divine body, at the same time it is despoiled of the robe and the little vestment that protected it." Indeed the crucifix in the museum of Cluny is covered by a short skirt with little folds, his head does not indicate physical suffering, but rather benevolence; his eyes are open, his hair is not in disorder, and it does not appear that the crown of thorns has been placed on his head. The primitive crucifixes, such as those of S. Sernin and Amiens, have the head covered by a royal crown. In the 12<sup>th</sup> century Jesus on the cross usually has the head bare, and it is only from the 13<sup>th</sup> century that is seen the crown of thorns enclosing his head, bowed toward the earth. Yet the tendency toward realism already makes itself felt at the end of the 12<sup>th</sup> century. There exists in the sacristy of the cathedral of Bordeaux a crucifix of ivory of great value as a work of art; it belongs to the second half of the 12<sup>th</sup> century. One sees that the artist has sought the imitation of nature, and the tortured deity is a suffering man. The head (1) however retains a calmness and a grandeur of expression, that merits the attention of artists. Only three nails fasten the members of Christ, while before that epoch the nails are four in number. The crucifix placed on a rood screen is ordinarily accompanied by the Virgin and S. John. The Virgin is placed at the right of the Saviour, S. John on his left. Sometimes an angel at the foot of the cross receives the blood of Christ in a chalice.



In paintings and stained glass, on the reredoses of altars, one frequently sees at the right of Christ the Church, that receives the divine blood in a chalice, on his left being the Synagogue, that turns away and whose eyes are covered by a veil. (Arts. Eglise, Synagogue). Usually Christ on the cross has a cruciform halo.

Note 1. p.443. Iconographie chretienne, histoire de Dieu. . p. 244. Paris. 1843.

Note 2. p.443. The crucifix of S. Sernin of Toulouse, and that of Amiens.

Note 3. p.443. Rather a short petticoat.

Yet this sign of divinity is omitted in many paintings and reliefs of the 13<sup>th</sup> and 14<sup>th</sup> centuries. In paintings, stained glass and reliefs, the artists have often represented above the arms of the cross the sun and moon under the form of busts of angels, weeping and holding two stars in the folds of their mantles, or again in the form of gilded disks, one radiating and the other indented. About the end of the 13<sup>th</sup> century, Christ on the cross as twisted and weakened, and the arms no longer form right angles with the body. The head of the Saviour is impressed by the expression of physical suffering carried sometimes even to exaggeration, as may be recognized by examining the stained glass of paintings of that epoch. (2).<sup>1</sup> This tendency to realism is still more sensible during the 14<sup>th</sup> century, and the artists came in the 15<sup>th</sup> century to give to the crucifix all the appearance of a human nature subjected to the most painful torment; this was to replace in the minds of the faithful the sentiment of the triumph of the divinity on the cross by the feeling of pity.

Note 1. p.446. From the old chapter hall of the cathedral of Bay-en-Velay. (fresco painting of the end of the 13<sup>th</sup> century).

### CRYPTE. Crypt.

The etymology of this word (cryptein, to conceal) sufficiently indicates its signification. The first crypts or consecrated grottos were cut in the rock or built of masonry underground, to conceal from the eyes of the profane the tombs of the martyrs; later and over those caverns venerated by the first Christians were erected chapels and vast churches; then crypts were established beneath edifices intended for worship, to con-

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contain there the sacred bodies collected by the piety of the faithful. Many of our old churches possess crypts that date in a very remote epoch; some are only rectangular rooms covered by tunnel or cross vaults, after the antique method, sometimes only ornamented by fragments of columns and capitals rudely imitated from Roman architecture, others are actual subterranean churches with side aisles, apses and niches. Crypts are generally entered by stairs that start at both sides of the sanctuary, or even on the axis of the choir.

The churches of France and of the banks of the Rhine present great variety in the arrangement and form of their crypts; several are constructed with a certain luxury, decorated by paintings, by marble columns and ornamented capitals, and are sufficiently large to contain a great number of the faithful; they most frequently possess two stairs, to permit the numerous pilgrims, who come to implore the assistance of the saints whose remains are deposited beneath their vaults, to descend in procession by one stairs and ascend by the other. Thus are avoided disorder and confusion.

With rare exceptions, crypts receive light by narrow windows opened on the exterior of the church or the side aisles of the sanctuary. This last arrangement seems to have been adopted when the crypts were excavated under the choirs of Romanesque churches surrounded by a side aisle. Thus the openings that admit air and light into the crypt open in the wall of the consecrated place. Then the choirs were elevated above the pavement around them, which adds to the solemnity of the religious ceremonies, and this permitted those present to see from the side aisle what occurred in the crypt. Most Rhenish churches still retain that arrangement, that we see adopted in a little church, several parts of which seem to date from the 6<sup>th</sup> century; we speak of the church of S. martin-au-Val of Chartres. "Originally one entered the crypt," says M. Paul Durand, in the faithful description that he has given of that edifice,<sup>1</sup> "by two little doorways placed at the right and left of its western part. These doors still exist. It is probable that formerly the spectator, placed in the great nave, could see the interior of the crypt through a middle or two lateral openings made in its western front, as may still be seen in several churches of the Centre and West of France." Between

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...arrangement churches with side aisles, apses and crosses. The  
...is the generally adopted by which these parts are joined  
...the sanctuary, or even on the axis of the choir.  
...The absence of transepts and of the tower of the choir  
...of great variety in the arrangement and form of their apses;  
...which are characterized with a double apse, composed of  
...distance, by which columns are arranged in depth, and  
...theological large to contain a great number of the faithful;  
...and some frequently possess two aisles, to permit the congre-  
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the raised floor of the sanctuary and that of the side aisle is a sufficient difference, that windows could be opened in the substructure of the arcades of the choir, so as to light the crypt and permit the interior of the crypt to be seen, whose vaults rest on two rows of four little columns each. Although the church may have been mutilated and partly rebuilt on several occasions, still the bases of the little columns of the crypt and some primitive capitals are work, that appears to belong to a very remote date, still near to the arts of the late empire, and presenting all the characteristics of the sculpture of the celebrated crypt of La Ferte-sous-Jouarre.<sup>2</sup>

Note 1.p.448. Rapport sur l'église et la crypte de S. Martin-en-val et Chartres, by M. Paul Durand. Chartres. 1858.

Note 2.p.448. See Archives des monuments historiques, pub. under the auspices of S. E. minister of State. Gide Edition.

Romanesque crypts rarely have a height over 9.8 to 13.1 ft. from floor to vault; it was then necessary for these vaults to be borne on a quincunx of columns, if the crypt occupied a very extended area. However the crypts being excavated under an apse or a sanctuary surrounded by columns, the wall that enclosed them at the east was generally semicircular. let us take as an example one of the oldest remaining crypts, that of S. Avit of Orleans.<sup>1</sup> S. Avit died between 527 and 529; his body was transported to Orleans and buried not far from the walls. "Childebert I, passing through Orleans to go to fight the Visigoths, desired to see the relics of the saint; he made a vow to build a church at that place where they were deposited, if he obtained the victory: he returned triumphant and fulfilled his engagement."<sup>2</sup> The church was afterwards sacked several times by the Normans, during the siege in 1429 and in 1562: it was torn down in 1710. Even a trace of it was lost, when in 1853 excavations made to extend the buildings of the seminary brought to light the crypt of S. Avit, which appears to us to belong to the structure of Childebert.

Note 2.p.449. See Rapport sur la crypte decouverte dans le jardin du grand seminaire d'Orleans, by M. Euzonniere.-- Bull. du com. de la langue, de l'histoire et des arts de la France. No. 5. p. 399. 1853.

Note 1.p.449. This crypt is now comprised in the buildings of the great seminary of Orleans.



We give (1) the plan of this monument. It will be observed that the entrance A is found below the semicircle, whose vaults are borne by 4 piers of octagonal section, at B is a rear hall (martyrium) separated from the apse by a masonry wall with openings. The little altar must have been placed in C and the body of the saint in D. We find analogous arrangements adopted in most of the primitive crypts; indeed the relics were deposited beneath the main altar of the sanctuary, placed before the apse occupied by the clerics. Fig. 2. gives the transverse section of the crypt on the line E G looking toward the open wall; and Fig. 3 is the longitudinal section on the line H I. The last section shows at A the tomb of the sacred body, at B is the principal upper altar placed in the sanctuary above the body of the martyr, at C are the seats of the clerics (chorus), and at D is the altar of the crypt. The construction of the crypt of S. Avit was made of rubble rudely dressed, separated by very thick mortar joints. The grotto designed to receive the sacred body is sometimes merely a recess, as at S. Germain of Auxerre, in the crypt of the cathedral of Chartres, and in the church of Vezelay; on the contrary the crypt is sometimes an actual nave enclosed by a side aisle. The last monument is well marked in the crypt of the cathedral of Auxerre, that we suppose was built in the 9<sup>th</sup> to 10<sup>th</sup> centuries. Here (4) is the plan of this crypt, today enclosed in structures of the 13<sup>th</sup> century. The martyrium A is a long hall with vaults resting on a quincunx of piers; the sacred body was placed at B, the little twin opening at the back recalls the opened wall that we found in the crypt of S. Avit of Orleans. An ambulatory C surrounds the martyrium; a single stairway remains now at D, but there is every reason to believe that another was found at E. The altar was placed at the back of the niche G. Thus the faithful descended by one of the stairs, could see the tomb of the saint through the openings arranged in the wall of the martyrium, make their prayers before the altar, and ascend by the other stairs. The crypt of the cathedral of Chartres had a very narrow stairs but an ambulatory with chapels of great extent.<sup>1</sup> The crypt of the abbey church of S. Denis presented the same arrangements before the rebuilding undertaken by Suger; in rebuilding the semicircle, the illustrious abbot retained them and added vast



chapels to the ambulatory surrounding the martyrrium, to which he left its primitive form,<sup>2</sup> probably not desiring to touch this consecrated place. Yet it was Suger that removed the relics of S. Denis and of his two companions from the crypt, where they had been deposited, to place them beneath the altar of the martyrs, at the back of the sanctuary.<sup>3</sup> (Art. Autel).

Note 1.p.452. See monog. de la cath. de Chartres, by M Lesus, pub. by ministry of public instruction and worship. (Incomplete); and Description de la cathédrale de Chartres, by obbe Eulteau.

Note 2.p.452. The martyrrium of S. Denis dates from the 9th or 10th century.

Note 3. p. 452. See Art. Chosse, Dict. du Mobilier Franc.

One of the largest crypts that has been erected is certainly that of the abbey of S. Benigne of Dijon. This crypt existed from the 6th century beneath the sanctuary of the church built by Gregory, bishop of Langres. In 1001 William, abbot of S. Benigne, undertook to rebuild the church and crypts, D. Planchet<sup>4</sup> prefers that William only repaired the work of bishop Gregory, and that he only built entirely the rotunda seen behind the apse. As for the church, we cannot know whether he rebuilt or repaired it, because it was entirely rebuilt at the end of the 13th century; but some recent discoveries<sup>5</sup> have laid bare the remains of the martyrrium containing the tomb of the saint and the cellars of the rotunda belonging to it; now these structures are identical and possess all the characteristics of the barbaric architecture of the beginning of the 11th century. It is then necessary to see there the monument of that epoch; yet it is certain that abbot William retained the masses belonging to the preceding structures, one recognizes the junctions, and finds fragments of an older structure again used as rubble.

Note 4.p.452. Hist. de Bourgogne.Vol. 1.

Note 5.p.452. Excavations made in Nov., 1888, under the direction of M. Suisse, architect, have uncovered the remains of the crypt of S. benigne and the lower story of the rotunda. These precious remains are to be consolidated and will be preserved.

The subterranean plan of that edifice, unique in France (5), shows clearly that the primitive crypts extended beyond the



parts A, under the transepts of the lod church. In these two galleries most probably ended the stairs of the crypt of bishop Gregory. Perhaps from the time of William, these old stairs had already been suppressed or judged insufficient, since two others had been constructed in the two round towers B, that flank the rotunda. The tomb of the martyr was at C, covered by a shrine and placed below the pavement of the crypt.<sup>1</sup> At D is found the chapel of S. John Baptist, erected in the 6 th century, if one believes D. Planchet.<sup>2</sup> The entire crypt, rotunda and chapel, are vaulted with rubble, except the middle part G, which remains open. This arrangement known, one understands how the processions of pilgrims must pass around the tomb of the saint, around the rotunda, ascend either by the stairs to the two round towers, or by one of the stairs originally opened at A. The circular crypt, not vaulted at the centre, allowed two stories terminated by a dome, of galleries to be seen, which must have produced a very beautiful effect. Before the rebuilding of the choir in the 13 th century, whose foundations are seen at E I I, it is to be believed that the extent of the subterranean story was greater still, and extended under the Romanesque choir and the transepts. Then one can regard the crypt of S. Benigne of Dijon as the largest of known crypts. This very remarkable monument was sold for the value of the materials at the end of the last (18 th) century by the commune of Dijon. (Art. Saint-Sepulchre). The contractors judged that the stones of the crypt were not worth the trouble to be taken to remove them, and this crypt has remained to us nearly entire. Today the people of Dijon accuse their fathers of vandalism in regard to the venerable remains of the ruins.

Note 1.p.454. The remains of this tomb are still visible.

Note 2.p.454. The substructure of this chapel not being uncovered, we cannot assign a precise date to its construction.

This arrangement of crypts, whose ambulatories are found outside the place reserved for the body was not the only one. In many crypts of small dimensions, the sacred body occupied a sort of niche or little apse built or excavated at the eastern end; then the faithful on descending the stairs found themselves before the sacred body as before an altar placed at the back of a chapel. The crypt of S. Seurin of Bordeaux, which dates from the 11 th century is constructed on that pr-



principle. Here (6) is its plan and (7) a perspective view of the interior, the tomb of the saint is placed in the middle of a sort of grotto preceded by a hall with three aisles, the central nave has a tunnel vault, as well as the side aisles.

There exists at Vicq in the district of Cannat a little and very curious crypt, in which the place of the reliquary is perfectly indicated behind a massive altar. A single stairway descends to that crypt, whose plan is here (8). The reliquary is at A and partly enclosed in the wall. The view (9) of the rear of the crypt needs no description.

Sometimes, but more rarely, crypts present in plan the arrangement of the upper story. Such is the beautiful crypt of S. Eutrope of Saintes, one of the largest existing in France. This crypt also presents a remarkable peculiarity, that it is abundantly lighted, and that its capitals are richly sculptured. We regard this structure as in part belonging to the last years of the 11 th century or the beginning of the 12 th. It is a nave (broad for a crypt) 17.7 ft. wide, terminated by a semicircle with side aisle around it and three radiating chapels. Here is its plan (10). At A is the tomb of the saint, composed of a slab placed on two steps.<sup>1</sup> The construction of the vaults of the crypt of S. Seurin of Saintes merits being examined with care; the vaults of the middle aisle belong to the 12 th century; they consist of transverse arches giving a half cylinder in section, between which are turned cross vaults of rubble and without groins, at the apse there are arches of rectangular section, that unite there in an enormous boss. Our perspective (11) gives the appearance of the interior of this crypt. The walls of the side aisles were repaired at the end of the 12 th and in the 13 th centuries, as well as the vaults of the two side chapels. The apsidal chapel was rebuilt, but the original arrangement is easily seized. Like the upper church the crypt is preceded by a vast narthex, whose walls alone belong to the construction of the end of the 11 th century.

Note 1.p.457. M. Letronne thinks that the funerary slab dates from the 4 th or 5 th centuries. An altar has unfortunately been placed before that tomb, and it destroys the grand effect of the crypt. On one of the slopes of this funerary slab is read in Roman capitals only the incised name- Eutropius.



It seems to us superfluous to multiply examples of these subterranean structures, that nearly everywhere present the same character. We have sought to show our readers the most remarkable varieties of French crypts, often these are only very simple cellars without side aisles and deprived of all ornament, or structures whose irregular shape was caused by ancient excavations, and were held to be preserved by a feeling of religious respect.

About the end of the 12<sup>th</sup> century, most of those sacred bodies, until then contained in the crypts, were placed in metal shrines and deposited under or behind the altars of the upper churches, thus one sees no crypts in churches entirely built since that epoch. The cathedral of Bourges forms a single exception; but the sloping ground on which was erected that edifice, much more than any religious idea, caused the adoption of the construction under the side aisles of the apse, of a subterranean church, that indeed is only a ground storey. At Chartres the architects of the 13<sup>th</sup> century retained the old crypt of the 11<sup>th</sup> century, because that crypt was held in singular veneration among the faithful, and that the solidity of the construction permitted the placing of the new structure on that old masonry. The programme according to which the French cathedrals were erected at the end of the 12<sup>th</sup> century did not comprise crypts, since those vast edifices then had a character both civil and religious. (Art. Cathédrale). Besides, one will observe that most of the old crypts of the parish or monastic churches were so arranged, that from the nave were seen the entrances to the crypt, the choirs must then be elevated above the pavement of the transepts by several steps, as for example in the abbey church of S. Denis. That arrangement suited a monastic church of which only a part was reserved for the public, but could not be accepted in our great French cathedrals, where it was especially required to offer to the multitude of the clergy a level area from one end to the other of the edifice,<sup>1</sup> except at the entrance of the choir, which with its side aisles was raised two or three steps.

Note 1.p. 459. For example at the cathedral of Paris, before the enclosure was established in the 14<sup>th</sup> century, the sanctuary was on a level with the side aisles of the choir; the altar alone was raised by several steps.

It seems to be impossible to maintain examples of these a  
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 was on a level with the side aisles of the choir; the  
 side aisle was raised by several steps.

On the contrary on the banks of the Rhine and in the provinces of the East, the cathedrals possessed from the 11 th c century and retained later their crypts half buried in the ground, so as to raise by several feet the pavements of the sanctuaries. Those cathedrals having two apses during the Romanesque period, one at the east and the other at the west, these two apses often each had its crypt lighted from the north and south side aisles, and by windows pierced in the semicircle without side aisles. At the cathedral of Besancon, before the mutilations that for a hundred years have successively modified the plan of that beautiful edifice, there were two raised sanctuaries and two crypts, the same arrangement at Verdun. At Strasburg one of the two crypts is retained beneath the choir much elevated above the nave. At Bamberg are still seen two sanctuaries at east and west with their enclosures and the two crypts. One of the most beautiful and oldest crypts on the banks of the Rhine is certainly the crypt of the cathedral of Spire, which according to the usual custom is half buried in the ground and receives light from the exterior. In England the crypt of the cathedral of Canterbury is far largest and the most interesting, having been successively enlarged as the edifice was extended.

All the old Romanesque crypts present traces of paintings, the very curious ones in Auvergne were entirely covered by legendary subjects often carefully executed. Under the choir of S. Benoit-sur-Loire exists a crypt allowing still to be seen fragments of painting, that belong to the 10 th or 11 th centuries. In a great number of crypts exist wells; frequently the water was regarded as miraculous.

We should not close this Article without mentioning a singular fact. Hugues of Poitiers in his *Histoire du monastere de Vezelay* (Book 4) says:- "Fire caught by accident in the vault over the sepulchre of the blessed Mary Magdalen, a friend of God; and this fire was so violent, that even the supports called beams by the French, that were placed in the upper part, were entirely consumed. Yet the wooden image of the blessed Maria, mother of God, which was placed on the floor itself of the vault, remained entirely protected from the fire and was only blackened." Is Hugues of Poitiers understood to speak of a wooden vault covering the crypt over the sepulchre of Mary



Magdalen, or of the upper carpentry of the church? What would cause one to believe that the fire destroyed the vault or rather the floor covering a crypt is the rest of the text; the monks having found relics in the wooden image of the Virgin, the surrounding people hastened to see that image so miraculously preserved. Gilon, prior of the monastery, explained before the multitude of people how should be repaid the acts of grace of the previous discovery, that had been made. "At this recital," adds Hugues, "all wept for joy, and when it was desired to restore under the vault of the sepulchre of the 'beloved of God', there was such a great multitude of people, etc." Thus one can believe that it was the vault or the floor serving as a vault of the crypt, that was burned. Yet there remains at Vezelay a portion of a crypt earlier than Gilon, (1165) and this part is vaulted with rubble; the other part of the crypt under the sanctuary dates from the last years of the 12 th century, i.e., was rebuilt after the fire. Thus one can admit, that under the sanctuary in the 12 th century existed a sort of raised floor under which was deposited the body of Mary Magdalen, and on which stood the wooden image of the Virgin.

#### CUISINE. Kitchen.

We have no accurate idea of what were the kitchens and their dependances among the Romans. Were they included within the houses as in our days, or were they arranged in separate buildings? The last hypothesis seems to us the most reasonable. It is to be presumed further, that the families in Rome, who did not possess numerous slaves and only occupied rented apartments, sent outside to purchase from the cookshops and other dealers the needed victuals at the time of need, as still practised today in most cities of southern Italy. The Gauls and Germans, like all primitive peoples, cooked in the open air. Gregory of Tours speaks of these repasts taken in the great sheds or wooden barracks, that the French kings built where they wished to reside for some time; in that case the foods were prepared outside in the midst of vast fireplaces built of bricks and of earth. In <sup>the</sup> Bayeux tapestry the men of William are seen cooking in the open air; it is true that this scene occurs at the time of the debarcation of his army



in England. Necham<sup>1</sup> remarks that it was customary to place the kitchens near the exterior of the houses, along the road or street. It was then necessary to cross a court to pass from the kitchen to the dining room; the meats were brought on spits and were carved on the sideboards<sup>2</sup> before presenting them to the guests.

Note 1.p.461. Alexander Necham or Nequam was a writer, who lived under the reigns of Henry II, Richard I and John; he has left descriptions of the houses of the 12 th century. Born at S. Albans in 1157, he was master of grammar in that city; he was abbot of Cirencester in 1213. (See Some Account of Domestic Architecture in England. Vol. 2. Hudson Turner. Parker edition. Oxford. 1861

Note 2.p.461. See Jos. Strutt. Angleterre ancienne.

In enclosures of Norman castles of the 11 th and 12 th centuries are frequently perceived circular areas 13.1 or 16.4 ft. diameter, portions of which are calcined; we think that these were primitive kitchens, that were nothing more than a sort of dome of earth with a flue at its top, in which were lighted fires for roasting or boiling meats. While retaining those primitive arrangements, they were perfected. In consulting the *Monographie des abbayes de France*,<sup>1</sup> there is noted in a cavalier view of the abbey of Marmoutier near Tours a kitchen termed *culina antiqua* (ancient kitchen).

Note 1.p.462. Lib. S. Genevieve.

This kitchen, whose external appearance is presented in Fig. 1, is a sort of great retort, that may have a diameter of 39.4 ft. outside. The vault in form of a bell is pierced by the principal chimney at the centre to allow the smoke to escape. It has inside five vast hearths, each furnished with a main flue and lateral flues as shown by the plan (2). Thus the smoke of the five hearths escapes by five direct and six lateral flues, each common to two hearths except those near the main entrance. This triple draft for each fireplace prevents the smoke from returning when the wind strikes one side. It must further be noted, that the flues are dominated by the top of the kitchen, and that in such a case, the draft is very insufficient for each fire, and must occur through a single flue. In *Art. Cheminee*, it may be seen that the constructors often divided the smoke flues, when these fireplaces were



very large. Here the excess of smoke could not find sufficient escape by the direct flues A and whirled around under the half dome of each hearth and escaped by the lateral flues B, each having two inlets C C. In spite of these precautions the smoke escaped beneath the principal vault, it found there the flues at D, and then the central flue. To make this structure understood, we give (3) at A the section on the line K L, and at B the section on the line K N of the plan. The kitchen of Marmoutier is entirely detached, but is near the refectory.

The same collection gives us the external appearance of the old kitchen of the abbey of S. Trinite of Vendome. That circular edifice possessed internally six fireplaces, each having two flues for the escape of the smoke, between the six fireplaces opened six windows (see plan in Fig. 4) abundantly lighting the kitchen. One will note that the preceding kitchen of the abbey of Marmoutier was without windows, and that the men were lighted only by the fires of the hearths, which sufficiently indicates that nothing was done in these kitchens but to cook meats and vegetables; later the kitchens were lighted by windows; stone tables were placed at the centre for preparing the foods before and after cooking; stoves were placed the mantles of the fireplaces. Before the 12 th century men ate only roast meats and boiled vegetables. The art of stewing was almost ignored. What were then necessary in the kitchen were great open fires, wide hearths suitable for placing numerous and long spits, and for suspending great pots.

The plan of the kitchen of the abbey of Vendome (Fig. 4) gives at A the horizontal section at the level of the hearths, and at B the horizontal section at the level of the windows.

The section (5) made at A on the line C D and at B on the line C E shows the arrangement of the hearths with their two flues, the six upper chimneys F opening at the top of the hemispherical dome and the great central flue are intended to cause a powerful draft, and to carry off the smoke inside.

Fig. 6 gives the external elevation of the kitchen of the abbey of Vendome. Behind each fireplace rises a buttress, caused by the weakening of the circular wall and the passage of the double flues beside the hearths.

This kitchen certainly dated from the 12 th century; it was a charming edifice, perfectly appropriate for its purpose.



Everyone can see today the beautiful kitchen of the 12<sup>th</sup> century of the abbey of Fontevrault, a kitchen that still exists, but which passes for a funerary chapel; which proves our perfect knowledge of matters and customs of the middle ages.

The kitchen of that old abbey is decorated internally by capitals supporting arches arranged in a manner perfectly suited to the purpose intended for the monument. At Fontevrault, better than at Vendome, the locations of the hearths are indicated on the exterior. The fireplaces occupy five sides of the octagon, and form as many great projecting niches between the buttresses. (See the plan of this kitchen, Fig. 7). The five fireplaces were formerly surrounded by flues now destroyed and closed. Four engaged columns bear four arches, whose keystones are abutted by four little internal flying buttresses A. The smoke that does not take its natural course by the flues B, finds above three of these four transverse arches, flues intended to take it outside. Above the four transverse arches are turned four small arches changing the square plan into an octagon; in the angles formed by these four little arches opened three flues C destined to remove the excess of the heat and smoke. Then finally a great central flue D, opening at the apex of a pyramid of eight sides, carried off the smoke that might be formed in the kitchen. All these flues except that at the centre have been destroyed.

Fig. 8 gives at A the section of that wall on the line K L; at B the section on the line M N, and at C the section on the line O P of the opposite plan. Formerly, openings made in the two walls R lighted the interior of this kitchen, whose entrance is at S.

Fig. 9 gives the external elevation of the kitchen of Fontevrault. We have thought to restore the destroyed chimneys, whose places are perfectly indicated.

Today, we are visibly far from those barbarous times, when men knew how to satisfy the common needs of life; in our chateaus and our great public establishments we place our kitchens in the ground story or in the cellars, so as to disseminate in the building the nauseous odor, that escapes from these kitchens; or indeed if we place them in separate structures, the rules of good architecture require them to occupy the commons, i.e., the wings almost always distant from the principal



building, so that it is necessary to bring the dishes through long corridors in carts, and that everything served on the table can only retain a lukewarm heat maintained by warmers.

During the middle ages the kitchens of palaces or monasteries inhabited by a great number of persons were important structures; indeed the kitchen counted for something in everyday life. The examples that we have just presented are actual monuments, well conceived and perfectly executed, one sees how the architects of those buildings have sought to obtain a very active circulation of air; indeed not only was air necessary for the use of such great hearths, but it also contributed to the quality of the foods used in cooking. A stay in those kitchens could not be unhealthy. The architects of the 13<sup>th</sup> century must necessarily perfect these dependances of monasteries and castles. They built kitchens in several stories, just as we shall soon see; they began by installing stoves there and not tables for carving the meats before serving them; they took great care to arrange a stone pavement so as to be able easily to keep them clean; sometimes they found means to utilize the smoke of wood for preserving certain meats.

There existed in the abbey of S. Pere or S. Pierre of Chartres a fine kitchen of the 13<sup>th</sup> century adjoining the refectory; that was circular and presented in the interior an ingenious arrangement, that permitted smoking a considerable quantity of meats. Either for the internal consumption of the monastery or for sale, the monks raised herds of swine, from which they made a product esteemed by lovers of salt pork and smoked hams. The great kitchen of the abbey of S. Pierre of Chartres was arranged so as to be able to smoke a considerable quantity of meats.

Fig. 10 presents at A the plan of the ground story, and at B the plan of the second story of this kitchen, built on a circular plan like the preceding. The hall contained six hearths C surmounted by a vault forming a sort of side aisle with an upper gallery. The smoke from the hearths passed through the openings D of the vault, and spread in the gallery E, whose walls were hung with hams on hooks. These two stories received external light by the windows G. After having swept around the upper gallery E, the smoke was led outside by the six flues H and by the central chimney K. The drawings and e



engravings, that we have been able to consult <sup>1</sup> do not give us the exact dimensions of this structure, but one can recognize that it was quite large, and that it must have had 39.4 or 45.9 ft. diameter.

Note 1. p. 472. *Se Monog. d'abbeyes de France. Lib. S. Genesee.*  
 Fig. 11 presents at A the section on M N, and at B the section on K L of this kitchen. One sees in section A the cells over each hearth against the walls on which were hung the meats. Buttresses rose behind the six hearths, both to abut the thrust of the vaults as well as to give stability of the points in the circumference at which the heat of the fires might crack the walls, as too frequently happens. By opening the lower windows was established a current of air that increased the draft of the smoke through the hole D, so as not to inconvenience the cooks; but the smoke filling the cells in the second story then escaped more slowly by the six flues H or by the central chimney. Thus there remained permanently in the upper gallery smoke seeking its exits, and the meats also had time to become impregnated by it; but the smoke could not return to the ground, due to the great central chimney, that established a powerful draft.

The external appearance of the kitchen of the abbey of S. Pierre of Chartres is presented in the elevation (12). Here the covering is made of carpentry covered by slates, and one sees how the great central chimney was maintained by eight flying buttresses indicated in the sections. To avoid steam, that could not fail to form under the central vault, if the extrados of this were in contact with the external air, the roof was raised and ventilation was established between the extrados of this vault and the carpentry. That isolation also permitted examination of the roofing and preventing leaks of rain.

The small area at disposal in castles and especially in palaces built in populous cities did not always permit the building of detached kitchens. They were forced to find their place in these buildings; but again in that case they were arranged with the greatest care and so as to not diffuse odor or smoke outside their walls. One still sees in the old structures of the palace of justice of Paris a hall vaulted on a quincunx of columns (13), with four wide fireplaces at the angles. Th



This hall looks out on the north quay beside the tower of the Horloge, and is known under the name of S. Louis' kitchens. Yet this structure belongs to the end of the 13<sup>th</sup> century or the beginning of the 14<sup>th</sup>, and is contemporaneous with the works erected by Philip the Fair. The mantles of the four fireplaces form in horizontal projection an obtuse angle, and their keystone is abutted by a sort of stone strut, as indicated by Fig. 14. Examination of the locality causes us to suppose that this kitchen had two stories. The lower kitchen, which now exists entire, was probably reserved for the courtiers, and the upper story for the service of the table of the king. In the palace of the Popes at Avignon still exists a kitchen of the 14<sup>th</sup> century; it is a vast pyramid with eight sides, hollow and built in a square tower, terminated by a single chimney; hearths are arranged in the lower walls. One does not fail to show this hall to visitors, as being that where the tribunal of the Inquisition had men roasted with closed doors. To roast men on a public place or in a tower for the greater glory of God is certainly a dismal means of bringing means of bringing them into the way of salvation; but to take the kitchen as a place for roasting human beings is a very ridiculous mistake.

Yet in castles as much as possible, and as practised in the monasteries, the kitchens were placed in a separate building. Here is one of those kitchens from the end of the 14<sup>th</sup> century, perfectly preserved, that belongs to the castle of Montreuil-Bellay near Saumur.<sup>1</sup>

Note 1.p.477. This castle once belonged to a duke de la Tremoille. We owe these drawings to M. Potouille, who has kindly made for us an accurate drawing of this little structure.

The plan (15) is square; in the interior are only two fireplaces A a. Stoves or soup kettles were probably placed at F. The two fireplaces each had their draft flue; at the centre of the vault is also another tall flue designed as usual to remove the steam formed in the interior of the room. This kitchen is attached at one side to a great hall B of the castle. Two small side doors are at C C, the latter opening on a gallery. There is still seen a third door at D, then at E is a very wide window with wall under, arranged like the front of a shop. Through this window was brought and received the



provisions from outside, and indeed is to be seen a trace of the little hood on the exterior, that sheltered the men stationed before the opening. The hood extended by means of a little suspended roof to over the door D.

The construction of the vaults is most curious to study, it shows us again how the architects of the middle ages freely utilized the principles, that they had discovered. Let us first give the section (16) of the kitchen of Montreuil-Bellay on the line O P of the plan. The central vault is a curvilinear pyramid of four sides with projecting ribs in the four re-entrant angles. These ribs are of stone and the curved sides are of brick; the projecting ribs support a circular stone ring, that receives the square central brick chimney, terminated by a lantern of cut stone, on the four sides of the square forming side aisles are turned tunnel vaults, those before the fireplaces being penetrated by their hoods. But to abut the four transverse arches and the two very heavily loaded ribs the constructor has turned half arches forming a sort of flying buttress turned toward the external walls. Thus these arches thrust a little outside and strongly maintain the central vault loaded by a heavy chimney. If we then cut the building on the line R S of the plan, we obtain the sketch (17), in which one sees in section how the diagonal arches L at the angles stay the four ribs of the central vault. Under the window at the right was probably placed one of the stoves or soup pots, and that window permitted the examination of the foods placed on that stove. Dating from the 14 th century, the use of sauces was very much approved in the art of cooking; men were no longer satisfied to serve on the tables roast or boiled meats. Stoves were necessarily required for preparing these condiments made more varied than in our days. At the beginning of our (19 th) century, a celebrated cook claimed that the English customs introduced in the culinary art were a loss to the art, that these were an evident return to barbarism; with the seriousness belonging to every cook sure of his merit, he sadly predicted the decadence of sauces, and consequently of society. The section made on the line T V of the plan gives the sketch (18) indicating how the hood of the fireplace penetrates the lateral vault, and how the flue must slant to the vertical wall. Fig. 19 presents the external el-

...the ... of the ... and indeed it is to be seen a trace of ...  
 ... on the exterior, that sheltered the men ...  
 ... the hood extended by means of a ...  
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 ... These ribs are of stone and the curved sides ...  
 ... the projecting ribs support a circular stone ...  
 ... that receives the square central brick chimney, termin-  
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 ... The section made on the line V of ...  
 ... (18) indicates how the roof of the ...  
 ... and the ...  
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elevation of the kitchen of Montreuil-Jellay, at the side with the window for provisions.

The court of Burgundy attached great importance to the service of the table, and during the 15 th century it was in the entire West, that where one ate and drank best. The descriptions of the feasts given by the dukes of Burgundy, that have been scrupulously preserved for us in the memoirs of Olivier de la Marche, permit one to suppose, that to prepare such a great number of varied dishes were required kitchens and offices arranged in the grandest fashion. Yet many dishes were cooked in advance; but a prodigious number of soups were served, of meats prepared with sauces, of stews, hot fish, and then pyramids of poultry or roast game. It was necessary for these dishes to be cooked at the time of the repast. Then in the vast kitchens of palaces or castles were only heated the hearths of vast fireplaces, before which long spits received the meats, but the andirons of these fireplaces supported small stoves at their tops, the soup kettles were heated by charcoal, then the tables on which were placed glowing embers, also served as a supplement, either for quickly making gravies or for dressing the dishes. They men adhered strongly to eating hot meats while warm, and one can understand how in those vast kitchens all equipped with hearths, the foods had no time to cool while they were placed in the dishes. The good arrangement of the chimney flues, and especially this central draft found in all the kitchens of the middle ages, constantly renewed the columns of air, and prevented the cooks from being suffocated, in spite of the extreme heat.

Since we have spoken of the table of the dukes of Burgundy, we must not omit the fine kitchen built during the second half of the 15 th century within the palace of the dukes of Burgundy at Dijon. That hall and its dependances were still entire some years since. Its plan is a perfect square (20); the central vault is supported on eight columns; at three sides these columns serve as jambs of three great double fireplaces A, whose hearths are only divided by pointed arches, and are surmounted by double rectangular flues. Two soup kettles or stoves are arranged at B; at C is an oven and at D a well with duct E communicating with one of the hearths. Thus one could fill the great kettles or boilers, that were proba-



probably suspended over one of the three hearths. This kitchen is lighted by high windows F and by a little lateral window G. At H rises the central chimney designed to remove the steam. At K a stone table received the foods after cooking them. The officials took them there to arrange them on the dishes. The slab of that table was heated underneath, so that these dishes could not cool.<sup>1</sup>

Note 1.p.482. See Vol. VIII, p. 253, of the Bull. mon. pub. by M. de Caumont.

Fig. 21 gives the section of this kitchen on the axis A'B'. The central chimney is supported on a small vault with square base (cloister vault), that rests on the great central vault reinforced by four diagonal ribs in the reentrant angles. These eight arches meet at an open ring at the centre and around its perimeter, as shown by the perspective detail P. According to custom a lateral sewer R received the water thrown on the pavement of the kitchen to keep it clean. The hearths were well arranged and included all the space afforded by the side aisle at their sides. The hoods were wider than those of the castle of Montreuil-Bellay, and must carry off the smoke perfectly, and render the construction more simple.

The kitchens of the middle ages, as we have just stated, nearly always contained stone tables or warmers, on which were deposited the meats and stews before carrying them into the hall of the feast. There still exists in the kitchen of the abbey of Mortain (Abbaye Blanche) two of these warming tables cut in granite, that we give here (22).

Our neighbors beyond the channel as well as we, appear to have arranged the kitchens of their monastic establishments or castles. There is seen at Durham a beautiful octagonal fireplace of the 14th century, with its dependances, offices, storeroom for wood and charcoal, etc. Whatever the dimensions of the fine arrangement of these kitchens of the middle ages, in certain cases they became insufficient for preparing food for great assemblages, the more so that then the lords kept open table for all comers. For the coronation of Edward I in 1273, all the area of vacant lands within the walls of the palace of Westminster was entirely covered by temporary sheds and offices to provide food for all that presented themselves. Numerous kitchens were also built in the same enclosure; but

probably proceeded over one of the three hearths. This kitchen  
is bounded by wide windows and by a large central chimney  
which the central chimney destined to remove the  
smoke. At a stone table received the food after cooking  
and the officials took them there to arrange them on the  
table. The kind of food eaten was great quantities, but  
the food would not cool.

See Vol. VIII, p. 252, of the Bull. non. pub.  
of the Government.

The kitchen of this kitchen on the axis of the  
chimney is supported on a small vault with a small  
vault (cylindrical vault), that rests on the great central vault.  
The kitchen is in the middle of the house and is  
the only stones meet at an open ring at the centre and around  
the kitchen, as shown by the perspective. The kitchen  
is a large kitchen and is a kitchen. The kitchen was  
the kitchen of the kitchen to keep it clean. The kitchen was  
well attended and included all the space allotted by the state  
to the kitchen. The house were wider than those of the  
kitchen of Montreuil-Bellay, and very carry off the smoke part-  
ly, and render the construction more simple.  
The kitchen of the middle ages, as we have just seen, is  
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The kitcheners beyond the canal as well as we, appear to  
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kitchen for wood and charcoal, etc. Whatever the dimensions  
of the kitchen of these kitchens of the middle ages,  
in certain cases they became insufficient for preparing food  
on great quantities, the kitchen of the house was  
and large for all covers. For the preparation of food I  
will give an idea of the kitchen which was built in the  
kitchen of the house, the kitchen of the house, the kitchen  
of the house to provide food for all the household members.

in the fear that these would not suffice, lead boilers were placed in the open air. The principal kitchen, in which poultry and other choice meats were to be cooked, was entirely uncovered to permit the smoke to escape easily.<sup>1</sup> To make of a kitchen a special detached building, perfectly suited to its purpose, would have been for the architects of the Renaissance, to dishonor the order of architecture. Since then it has been desired to disguise these essential services, they are relegated to the cellars, or placed as may be in the main building, with the risk of inconveniencing the occupants of the chateaus. It is first desired to present symmetrical facades and regular courts, but since it is necessary to dine, whatever love one may have for symmetrical architecture, the odor of the kitchen and the noise of the servants extends at certain hours through a good portion of the palace. In public establishments, such as asylums, barracks, seminaries, monasteries and colleges, instead of the great well ventilated rooms well arranged in the middle ages, men have been compelled to take in the ground story or underground (always to satisfy the rules of beautiful architecture) a room often surrounded, dark and damp, difficult of access, to install there the kitchen and its dependances, instead of those broad hearths, before which meats roasted while absorbing as much oxygen as they could take up; there have been placed stoves suited (it is said) for all sorts of cooking, equipped with ovens, from which all foods come after having acquired nearly the same taste. In these cast iron laboratories the meats do not roast but dry up; vegetables while boiling take an insipid flavor; air is lacking to these different dishes, and air for a great part enters into their nutritive qualities. Chemistry declares that a leg of mutton cooked in the open air or in one of these cast iron crucibles presents the same elements on analysis, we admit it; but our palate, that is not a chemist, perceives a great difference between them; our stomach digests badly those foods smothered in cooking, dry without savor. It is true that we can aid digestion by going to see the beautiful regular facades of our public edifices, count the number of their columns, of their arches and windows.

Note 1. p. 484. See Dom. Arch. of the middle ages, 14 th century. p. 85. Oxford. Parker.



You, architects of our old castles, our old hospitals, our religious houses, what would you say if you enter most of our public establishments, if you see how are arranged the services most essential to the common life? <sup>1</sup>

Note 1.p.485. Since this refers to kitchens, it must indeed be recognized, that in many of our establishments of public instruction and barracks, particularly in most of our seminaries, the sight of those offices is made to take away any appetite from those most hungry.

#### CUL-DE-RASSE -FOSSE. Dungeon. Oubliette.

If we credit most of the writers that have treated of the middle ages, who have attempted to trace the customs, there was not a monastery or castle in France, which did not have in its foundations at least one oubliette destined to receive those men, that were desired to disappear. We have seen many castles and a good number of monasteries, and we have never been able to find this sort of oubliette in form of an inverted cone, said to be destined to receive unfortunates, that were not only deprived of the light of day, but who could neither sit nor lie at the bottom of these pits. When during the middle ages it was desired to make a man disappear, he was hung high and quickly, then cast into a pit, or he was simply killed, taking care to bury him in some remote corner; but men rarely amused themselves by these strangely barbarous refinements. All castles containing deep cellars opening only by a hole pierced in the vault, cellars that were actual storerooms for receiving grain, roots and provisions, but in which was placed no person. Sometimes these pits are built as inverted cones; they are then icehouses. Some have also desired to see in a great number of privy vaults oubliettes, and there is not a castle in which the guide of the place does not show you privies raised to the rank of oubliettes. The prisons and dungeons exist in nearly all monasteries, castles and official buildings; but these prisons are perfectly arranged for the intended purpose, they are unpleasant, but they are only rooms more or less large, more or less lighted or entirely dark; they are not oubliettes. Those who built them appeared to wish to make them safe but sanitary, as much as prisons could be made. (Art. Prison).



## CUL-DE-FOUR. Half Dome.

Vault of a quarter sphere resembling indeed the back of a bread oven. The semicircle containing the tribunal of the Roman basilica was covered by a quarter sphere; that arrangement was imitated during the first times of Christianity and persisted in the East until about the middle of the 12<sup>th</sup> century. (Arts. Architecture Religieuse, Cathedrale, Construction, Eglise). In the primitive Roman church the clergy was arranged around the semicircle, and the altar was found between the choir and the believers. Windows were pierced in the semicircular wall of the apse and lighted the assembly of the clergy, above these windows was built the half domical vault, usually decorated by paintings or mosaics. (Arts. Mosaïque, Peinture). One still sees in France many apses vaulted by half domes in Poitou, Normandy, Auvergne, Lyonnais and Burgundy. It sometimes happens that the vaults of the naves and transepts are already Gothic in the system of construction, and that the apses retain the Romanesque half domes. One can cite the cathedral of Langres among other remarkable examples of this kind. The form of the quarter sphere had been so well adapted for apses in the first times of the middle ages, that it seemed consecrated; the clergy only renounced it with difficulty when Gothic art, entirely adopted in religious structures no longer permitted the mixture of the former methods of construction.

## CUL-DE-LAMPE. Pointed Corbel.

We have adopted the system of giving in this Dictionary the words sanctioned by use, without discussing their etymology or value; but we must confess that the word "cul-de-lampe" as applied for two or three centuries, is justified by no good reason. The bottom of a suspended lamp terminating in a point could give the idea of applying the name to certain pendant keystones of the 15<sup>th</sup> and 16<sup>th</sup> centuries; but men did not stop there; they gave that name to every corbelled support, that is not a corbel, i.e., does not present two parallel surfaces perpendicular to the wall. And to avoid longer explanations (1), A is a corbel and B a "cul-de-lampe". For lack of a better term, we then accept it.

The Romans employed pointed corbels, or rather consoles and



corbels to support little orders of columns attached to the surfaces. This was one of the traditions of the late empire, that the middle ages retained and perfected. This principle was purely ornamental in Roman architecture, and even became one of the means of construction most commonly employed during the Romanesque and pointed periods. During the Romanesque epoch, because the first who had the idea of placing vaults on the plan of the Roman basilica, after having erected in place of the slender antique Ionic or Corinthian column, heavy cylindrical piers A (2) were much embarrassed to know how to find points of support for the imposts of the transverse arches. They then thought of placing over the junction of the archivolts of the side aisles projecting stones, on which then raised then the engaged columns C. They generally gave to these projecting stones the form of a pointed corbel, because indeed that form diminished at the bottom best accorded with the junction of the two extradoses of the archivolts. It is unnecessary to state that these primitive pointed corbels are barbarous; they are sometimes merely inverted cones slightly fluted (3), or human heads and those of animals rudely sculptured. But these pointed corbels by their position itself attracted the eye; sometimes placed near the eyes, men sought to make of them remarkable works, when Romanesque sculpture became less rude; the execution was entrusted to the most skilful hands. Already in the provinces that possessed good schools of sculptors at about the end of the 11th century and beginning of the 12th, one finds pointed corbels as remarkable by the style as the purity of their execution. One of the most beautiful that we know from that epoch is found at the entrance of the choir of the upper church of Chauvigny (Poitou); it supports a column of the transverse arch, and was placed to take the lower part from the pier, leaving more width to the nave for placing benches and stalls.

Note 1.p.487. See the ruins of the palace of Diocletian at Spalato.

We give this pointed corbel (4) in front at A and in profile at B. By its style this sculpture recalls the best Greek Byzantine sculpture. Where did these western artists of the beginning of the 12th century obtain those types? That is what we shall examine in Art. Sculpture.



There existed in the refectories of the abbeys of the 12<sup>th</sup> and 13<sup>th</sup> centuries pulpits for readers, that were supported on magnificent pointed corbels, according to authors that had seen them, for there no longer remain only mutilated traces of those sculptures. The pointed corbel of the pulpit of the reader of S. Martin-des-Champs at Paris (Art. Chaire, Fig. 3) passed for a masterpiece. These last pointed corbels were composed of several corbelled courses, and the ornamentation was combined according to the height of the courses or extended over all; most frequently it was a tree putting forth branches and leaves mingled with birds. When the system of vaulting really belonging to the middle ages was invented, these vaults consisting of independent members, transverse, diagonal and side arches serving as ribs for the filling, the arches sprung from the construction; they must then either rest on piers forming projections from the faces of the internal walls, or on corbellings, pointed corbels. In halls that by their purpose must be surrounded by benches, wainscoting and furniture, men avoided with reason supporting vaults on piers, whose projections might have been inconvenient. Then the pointed corbels frequently played a very important part; for if the different arches of the vaults were strong and numerous, it was necessary for their pointed corbel to form a broad and projecting bearing.

In the old abbey hall of Vezelay, known now by the name of the low chapel, a hall that was nothing but a sacristy or a place of assembly for the religious before passing into the choir, the vaults of the 12<sup>th</sup> century, round arched but constructed with pointed vaults, rested on pointed corbels formed of three courses and an impost (5). This sculpture was destined to be seen very near, since the lower course is not more than 6.6 ft. above the floor, and is executed with much refinement, while leaving to the stone all necessary strength.

More even than the Romanesque epoch, the 13<sup>th</sup> century desired to diminish the importance of the points of support on the floor and to remove all projections from the interiors, and did not fail to employ pointed corbels for supporting the vaults. The sculptures of that epoch enriched them by figures, sometimes quite important, by heads and especially by foliage; they even went to give them entire compositions, especially if



they needed to give to these pointed corbels a strong projection to bear wide and deep arches. Even then, in the fear that at the imposts of these arches might split under the load of two or three courses composing the pointed corbel, they set a first corbel, then a projection on this corbel, finally placing the second; thus they distributed the load over a greater height, and did not have to fear ruptures.

There is still seen in the angle of the north transept of the cathedral at Agen a pointed corbel composed on that principle, and which by itself is a little monument receiving two great side arches and a transverse arch of great span (6). The construction of this support is no less remarkable than its design. The first course, the true pointed corbel is at A, deeply engaged in the two surfaces extending at right angles. The upper bed of this course is at B. The figure and the work behind it up to the band C is a single block of stone. The two side columns are detached, and each in one piece of stone set on end; their capitals are engaged in the walls; the upper band receiving the impost of the diagonal and two side arches is also engaged in the construction. In plan this corbel gives the sketch (7), assuming the horizontal section made at the level D. This corbel is placed at a very great height and the execution is coarse.

Burgundian architecture is rich in pointed corbels of very remarkable originality and beauty of execution. The resistant nature of the limestones of that province authorizes boldness, that one could not permit in Ile-de-France, Champagne and Normandy, where the materials are generally of a nature less firm. The school of Burgundian sculpture of the 12th and 13th centuries further is endowed with a strength and fertility in composition, that we have many times had occasion to mention in the course of this work, and whose development we shall explain in Art. Sculpture.

The little church of S. Pere or rather S. Pierre-sous-Vezelay, among other Burgundian edifices, presents a great variety of pointed corbels. Here are two (8, 8 bis), that receive groups of columns separating the arches and vaults of the nave: they are each composed of two courses, that are perfectly indicated in the arrangement of the ornament. One of these corbels represents the vice of avarice under the form of the

only seated on five in some places, a small group  
 and on last side and deep across. When seen, in the last an-  
 to the surface of these stones might solve under the load of  
 two or three courses comprising the pointed corbel, they are  
 three corbel, then a transition to the corbel, which is  
 and the second; and they distributed the load over a three-  
 corbel, and did not have to bear together.  
 which is well seen in the angle of the north passage of  
 the cathedral. It is a pointed corbel, which is well im-  
 and which by itself is a little moment receiving  
 and a transverse arch of great span (6).  
 the corbel of this kind is in the same position  
 in the first window, and the corbel is in the  
 which is in the two surfaces extending at right angles.  
 at the end of this course is at 8. The fifth and the sixth  
 corbel is up to the band 9 is a single block of stone. The  
 two fifth columns are detached, and each is one piece of stone  
 or so and this corbel is placed in the wall, and the  
 a band receiving the weight of the arches and the side arch-  
 is in the same position in the north passage.  
 over the sketch (7), assuming the horizontal section made at  
 the level of the corbel is placed at a very great height and  
 the transition is coarse.  
 the transition is fine in several corbels of very  
 certain originality and beauty of execution. The (eighth)  
 corbel is the first of the last group of corbels, which  
 has and could not occur in the de-france, Cambray and Nor-  
 only, which are naturally the result of a single line of  
 the usual of Burgundian sculpture of the 12th and 13th cen-  
 turies. It is endowed with a strength and facility in a  
 composition, that we have many times and occasion to mention  
 in the course of this work, and which is a result of a single  
 line of the sculpture.  
 The first corbel of St. Peter or rather St. Pierre-sous-Vers-  
 is, which is a Burgundian corbel, between a group of  
 of pointed corbels. Here are two (8, 9 etc.), that receive  
 the weight of columns separating the arches and vaults of the na-  
 ve. They are the most ancient of the corbels, and the most  
 distinct in the arrangement of the ornament. One of these  
 corbels represents the vice of avarice under the form of the

bust of a man with a full purse hung on his neck; two dragons devour his ears, remaining deaf to the complaints of the poor.

To make understood the different modes of rendering the same motive by the schools of architects of the same epoch, we give (9) one of the corbels supporting the clusters of little columns of the vaults of the lantern of the cathedral of Laon. This corbel is little earlier than the two last. One sees how the sculpture of Ile-de-France is restrained, if we compare it to that of Burgundy. It is scarcely possible to compose in a simpler and more graceful manner a support intended to bear three little columns by corbelling. This angel's bust that projects from the wall appears to lean on the course serving it as a starting line, by its natural pose it appears to carry without effort the three shafts, so well placed on its head and its two wings.

Burgundy surprises by the boldness of its conceptions, its plant sculpture, abundant and broad, cut in hard stone by skilful and sure hands, charms us; never did its school attain that purity of style and delicacy of taste, that we find in the royal domain, Champagne and Beauvoisis, after the 12<sup>th</sup> century.

Sometimes the pointed corbels take the form of a simple capital without a column; the capital is engaged in the wall, and in place of the astragal the sculptor has cut a bunch of leaves. Beautiful corbels of that kind are seen bearing the low arch of the side aisle of the choir of the cathedral of Auxerre; but these do not have the breadth of execution of the two or three corbels that hold a similar place in the aisles of the little church of Clamecy (10). (About 1230). The Normans, who are reasoners, desire these pointed corbels to spring from the wall just as vegetation springs from the joints of the stones. Here (11) are several corbels supporting the corbelled gallery, that surrounds the piers of the nave of the cathedral of Rouen above the archivolts (about 1230), presenting that peculiarity. Sometimes in Normandy the pointed corbels are also composed of a capital placed on the end of a column bent at right angles and penetrating the wall. The Normans did not understand in the 13<sup>th</sup> century, that a capital remains suspended without support.

At the middle of the 13<sup>th</sup> century, the columns or little

front of a wall with a full porch hung on his neck the statue.  
 Between the two, remaining dead to the complaints of the body.  
 It was determined the different modes of rendering the same  
 subject by the schools of architects of the same epoch, we give  
 a plan of the temple supporting the statue of the Virgin Mary.  
 The statue of the Virgin Mary is the subject of the cathedral of Laon. It  
 is a little earlier than the two last. One sees how  
 the sculpture of the Virgin Mary is restrained, if we compare  
 it to that of the Virgin Mary. It is scarcely possible to compare it  
 to a statue and more graceful manner a statue intended to be  
 seen in a little column by corbeling. This statue's bust that  
 is seen from the wall appears to lean on the corse serving  
 as a supporting line, by its natural pose it appears to car-  
 ry without effort the three shafts, so well placed on its head  
 and the two wings.

Hardly surprised by the boldness of its conception, its  
 elegant sculpture, abundant and broad, and in part even by its  
 light and airy nature, carved and carved in the same style.  
 The quality of style and delicacy of taste, that we find in a  
 the great domain, the same and the same, after the 12th  
 century.  
 Sometimes the statue supports the Virgin Mary in a statue and  
 all without effort, even though it is placed in the wall,  
 and in place of the natural line of the statue the wall is  
 carved. The statue of the Virgin Mary is seen in the wall.  
 The side of the side of the corner of the cathedral of  
 Laon, and these do not have the breadth of execution of a  
 wall of three corbels that hold a statue placed in the air.  
 The side of the side of the corner of the cathedral of Laon  
 is of the little corner of the corner of the corner of the corner  
 of the corner, and are reasonable, desire these pointed corbels to  
 bring from the wall that an extraordinary support from the wall.  
 The corner of the corner. Here (11) are several corbels supporting  
 the pointed statue, that supporting the statue of the Virgin  
 Mary the cathedral of Laon (the statue of the Virgin Mary).  
 The pointed statue. Sometimes in Normandy the point-  
 ed statue is also composed of a capital placed on the end of  
 a column and at right angles and perpendicular the wall. The  
 corner of the corner is seen in the corner, the corner of the corner  
 is the corner of the corner of the corner of the corner.

columns receiving the imposts of vaults are no longer borne by corbels; they descend to the ground, thus pointed corbels are rarely employed, except to support statues, attached to these columns, or accessory architectural members. These kinds of corbels are found very frequently built into edifices after the end of the 13<sup>th</sup> century.

One sees in the interior of the upper S. Chapelle of the palace at Paris beautiful pointed corbels attached to the shafts of the columns receiving the principal arches of the vault. These corbels to the number of 12 bear the statues of the apostles at life size; they are very rich, and cut in the height of one course of lias stone, and consist of a slab or moulded abacus, whose fillet is incrustated with stained and gilded glass, with a very slightly curved and very flat bell, combined with the shaft of the column. Around these corbels are grouped tufts of leaves carved with charming flexibility, painted and gilded (12). These corbels perhaps do not have a character sufficiently monumental; but it should not be forgotten that they are placed in the interior at about 10 ft. from the floor, and that as well as the statues, they are all made to break the dry lines of the columns ascending from the bottom.

The internal sculpture of the S. Chapelle of Paris is most delicate, and already in the edifice the imitation of the flora is carried very far.

If we take one of the corbels serving as support of some statues decorating the western gable of the church of S. Pierre-sous-Vezelay (13), we shall again prove the differences of style, that separate the sculpture of the French and Burgundian schools.

The composition of the internal corbel of the S. Chapelle is wiser and particularly more refined than that of this Burgundian corbel (both date from the middle of the 13<sup>th</sup> century); but in this last ornament the monumental character is certainly better felt; its composition is broad, like the execution; there is a strength and a remarkable firmness of style.

Let us state in passing, that nearly always corbels placed either in the interior or on the exterior of edifices are painted in vivid colors; the grounds are red, reddish-brown or slaty-blue, the leaves are light green, yellow ochre or gold. Men then strongly held to giving these supports a great deco-

which remains the record of various and no longer borne  
to occur; that is to say, the record of the various  
and rarely employed, except to support statues, and  
those which, or numerous architectural members. The  
of corbels are found very frequently both in edifices  
from the end of the 12th century.

The most in the interior of the great St. Chappelle of the  
which Paris beautiful pointed corbels attached to the en-  
facing the column capital; the principal object of the cor-  
el these corbels to the number of 12 bear the statues of the  
located at the same time; they are very small, and set in the  
of the course of the stone, and consist of a slab or  
which is inserted in the wall, and is shaped like a  
and which, with a very slightly curved and very thin bell, a  
united with the shaft of the column. Around these corbels  
the shaped cuts of leaves carved with carving flexibility,  
and which (fig. 12). These corbels which do not have a  
sufficiently monolithic; but it should not be forgot-  
that they are placed in the interior as about 10 ft. from  
the floor, and that as well as the statues, they are all made  
in the very line of the column ascending from the bottom.  
The internal sculpture of the St. Chappelle at Paris is most  
elaborate, and already in the edifice the imitation of the fin-  
is decided very far.

At the same time one of the corbels serving as support of some  
other ornament, the statue which is the support of the fin-  
is placed (fig. 13), we shall again prove the differences  
which separate the sculpture of the French and Eng-  
lish schools.

The sculpture of the internal corbel of the St. Chappelle  
is good and particularly more refined than that of this Eng-  
lish school (both date from the middle of the 13th century).  
In this last ornament the monumental character is a  
character which is felt; its composition is good, like the ex-  
terior. There is a strength and a remarkable firmness of style.  
The statue is placed in the interior of the edifice and on  
the side of the column capital, and is placed in the line of the  
column, the leaves are light green, yellow above and white.

decorative value, to make them prominent.

Sculptors during the 14 th and 15 th centuries, to decorate the corbels supporting statues, chose by preference the representation of the vices opposite to the qualities of the personages they were intended to receive, or again the figures of their persecutors, or the scene of their martyrdom. many of our old statues of churches having been broken during the religious wars or at the end of the last (18 th) century, the corbels merit study from the point of view of iconography, for they can serve in determining the statues placed above them. Thus under the statue of S. Peter is frequently seen the figure of Simon the magician, and under that of the Virgin is the dragon with a woman's head. For the person famed for his continence the corbel represents a scene of lewdness (14); <sup>1</sup> this is a young noble seeking to violate a nun.

Note 1.p.500. Corbel of the 14 th century placed on the interior of the south wall of the cathedral of Auxerre, the statue is wanting.

Beneath the feet of Christ teaching, whose statue is attached to one of the piers of the old cathedral of Carcassonne at the left side of the entrance to the choir, is sculptured a magnificent corbel, that seems to us to represent Judas after his condemnation. A dog or an unclean beast is tearing him. Vine leaves crown this scene (15).<sup>2</sup>

Note 2.p.500. this sculpture dates from the beginning of the 14 th century.

Some of these vices are too frankly rendered, and have caused it to be supposed that the sculptors of the middle ages pleased themselves by placing under the eyes of the public scenes rather lively, even in the churches. A false zeal or often an imagination too easily excited have thus placed to the account of those artists misdeeds, that they did not commit. Until the 14 th century one can see in these representations only the image of a vice in opposition to a virtue. Besides, before that epoch there was great restraint in the mode of representing these vices. Later when the arts of the middle ages fell into affectation and the puerile imitation of nature, it appears evident to us, particularly if one refers to the customs of the 15 th century, that the artists having to personify vice pandered to the spectators in the representation



of scenes explaining that vice to the observers. These abuses have existed in epochs of decadence, and the arts of the two last centuries did not fail to fall into it. (17<sup>th</sup> and 18<sup>th</sup>).

The corbels supporting the imposts of arches or statues often appear in the architecture of the 15<sup>th</sup> century, and they show the taste of that period. Their abacuses are often concave sided (16); they are elongated and are composed of two or three courses. Geometrical lines assume importance.

The sculpture reproduces subdivided leaves frequently imitated with a perfect study of nature. The entirety of these compositions however does not fail to present confusion, are too labored with too delicate details, and that are not in scale with the edifices. These are little masterpieces, that the stonecutters are pleased to fashion lovingly in their workshop, outside the direction of the master of works. One no longer feels in these compositions the monumental harmony, that we always find during the 12<sup>th</sup> and even also during the 14<sup>th</sup> centuries.

At the end of the 15<sup>th</sup> century pointed corbels, especially in civil architecture, are employed with prodigality, and present masses better combined and more varied than those of the middle of that century, that weary by the uniformity of the geometrical forms and the labored sculpture. There existed in the mansion de la Tremoille at Paris very beautiful corbels under the vaults of the portico and in the grand stairway, whose newel is preserved at the Ecole des Beaux Arts. One of the great corbels of that portico, that we give (17), represents an angel with a child at its right bearing a palm leaf; on the left this angel seems to repulse a little siren, the emblem of lewdness as all know. Was this innocence or chastity protected by the guardian angel? <sup>1</sup> Also sometimes corbels belonging to civil edifices represent scenes from the romances or tales known to all.

Note 1.p.503. This bracket, of which we made a drawing before the destruction of the mansion de la Tremoille, is probably lost, for we have not found it among the fragments placed in the court of the Ecole des Beaux Arts.

In the 15<sup>th</sup> century, heraldic arms, emblems, scenes recall certain events of the life of the nobles or citizens who built. Thus in the charming mansion of Jacques Coeur at Bourges, behind a wardrobe destroyed several years since, was found a ve

...and last vice to the observers. These artists  
have created in scenes of domesticity, and the arts of the two  
and sometimes did not fail to fall into art. (17 in and 18 in).  
The corbels supporting the impost of arches or statues of-  
appear in the architecture of the 15th century, and they  
are the basis of that period. Their spaces are often con-  
sidered that they are elongated and are composed of two or

...The sculpture throughout exhibits a certain uniformity in  
...a perfect study of nature. The entirety of these cor-  
bels however does not fail to present confusion, and too  
much with too delicate details, and that are not in ac-  
cord with the edifice. There are little masterpieces, but the  
characters are dressed to fashion lovingly in their work-  
...the direction of the master of works. One no less  
...the 15th century, and even during the 16th

...At the end of the 15th century painted corbels, especially  
...are employed with profusion, and com-  
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...Paris very beautiful corbels  
...of the corbels and in the great gallery.  
...is preserved at the Musée des Beaux Arts. One of  
...of that period, that we give (17), shows  
...at its right bearing a child; the  
...this angel seems to resemble a little angel, the  
...as all know. Was this innocence or chastity  
...by the guardian angel? Also sometimes corbels  
...from the romances  
...to all.

...This brooch, of which we make a drawing 187-  
...the sculpture of the middle of the 15th century, the group  
...for we have not found it among the fragments placed  
...of the Musée des Beaux Arts.  
...the life of the nobles or citizens who built.  
...the sculpture of the 15th century, and that is  
...and a certain number of years since, and that is

very curious corbel. This corbel is placed in the hall that passes as having been the treasury (not without reason), the cabinet of Jacques Coeur. Indeed this hall is well closed by an iron door, and it is found in one of the old towers against which the palace is built. It even seems that the wardrobe, that concealed the corbel was placed there from the origin of the building, for the old tiles did not exist below it.

Here (18) is a representation of the corbel in question.

At the left is a fool holding a boucle in his right hand, the left trying to catch flies placed on the trunk of a fruit tree. Turning his back to that figure and in the middle of the corbel is Jacques Coeur (or at least a person recalling his features) in the elegant costume of a noble with a dagger at his side. With his left hand he points to a small square basin at his feet filled with water, in which is reflected the image of a bearded head, crowned and placed in the tree above the fountain. A scroll extends to right and left of the royal head.

On the right is a woman lying on a rich rug thrown on blossoming grass; she is crowned and raises the right hand to her crown as if to remove it; with her left she raises the bottom of her robe trimmed with fur. A very rich collar surrounds her neck. The right end of the corbel is occupied by a third tree. The gesture of the woman is rather equivocal, the bearing of the man is discreet; only he seems to advance with mystery. We do not know any tale, account or romance that can explain this curious sculpture. One would be tempted to see in it an episode of the life of Jacques Coeur, who had been accused by his enemies before the king, to overthrow him with more certainty, of having purchased the favors of Agnes Sorel. Here the personage that we believe represents Jacques Coeur appears to be solicited by the reclining woman; by indicating the image of the king reflected in the fountain, he seems to indicate the witness of that scene and to recommend prudence.

If this sculpture was executed before the disgrace of Jacques Coeur, although it was placed in a secret place, it must be confessed that it was a singular conceit or act of imprudence. If only sculptured after his restoration (which would seem more probable), that would cause it to be supposed, that he desired to place before his eyes the memorial of one of the



the principal causes of his misfortunes, as a perpetual lesson. The person of the fool would add weight to the last hypothesis. Is it not there to show that libertines with gallant adventures, were these of a nature to flatter their vanity, resemble the fool that passes his time in catching flies?

However that may be, this example sufficiently explains why the sculpture of the corbels in the edifices of the middle ages merits observation; it may sometimes aid in explaining facts belonging to the customs, or certain historical episodes of great interest.

Here (18) is a reproduction of the corbel just described,<sup>1</sup> the lower part of which is unfortunately mutilated.

Note 1.p.504. Notice pittoresque sur les antiq. et mon. du Berri, published by M. Hozé. 1834. M. Hozé first mentioned the existence of this curious sculpture in the mansion of Jacques Coeur.

From the 12 th century, the constructors frequently supported turrets containing stairs, or serving as lookouts on angle buttresses; but the perimeter of these turrets projecting for part of this area, is indicated in the plan (19), there remained the triangles A, which it was necessary to support by corbelling, whose lower course at least was cut in the form of a pointed corbel.

The remains of a building of the castle of Veas near Morienval shows us also an angle turret of the 12 th century, which is thus supported in the reentrant angles by corbellings commencing with a pointed corbel (20) cut in the form of the end of a beam. (Arts. Echauguette, Tourelle). It is very rare to find corbellings of turrets with pointed corbels sculptured during the 12 th and 13 th centuries; still we possess some examples of them in a beautiful style.

Certainly the most remarkable are seen beneath the stairway turrets of Notre Dame of Dijon, first half of the 13 th century. It is still in Burgundy, that we give here (21) a specimen of its school of sculptors. This corbel is composed of three courses, each of a single block. In the wide hollows twist or ramp fanciful animals, sculptured with strong energy and extreme skill. The faces of these beasts are rendered by a sculptor observant of nature, although he could only take his models from his imagination,<sup>1</sup>. When one examines closely this s



singular menagerie,<sup>1</sup> he is struck with astonishment before the realism given by the hand of the artist to those impossible beings. All bearing the character of brutal ferocity belonging to the wild beast. Their members are attached by an attentive and knowing observer. But all the sculpture of the facade of Notre Dame of Dijon would be worthy of being cast and placed in a museum, it is the masterpiece of the Burgundian school of the 13<sup>th</sup> century.<sup>2</sup> These corbels, like all the sculpture of that facade, were painted. The architects of the middle ages had so fully adopted that habit of coloring external corbels, that under one of the angle turrets of the synodal hall of Sens, that dates from about 1245, there exists an owl in the form of a support; this owl was painted red, although there are no traces of coloring on the rest of the exterior of the edifice. After the example just given, the sculptured corbels beneath the turrets of the 14<sup>th</sup> and 15<sup>th</sup> centuries would appear common, so we limit ourselves to these; besides, these corbels are generally composed of bands of leaves presenting nothing in particular. At its origin, the Renaissance did commit the fault of employing pointed corbels in architecture; but these last corbels nearly always reproduce the form of a capital without a column, possessing a base in form of a rosette beneath the lower bed, instead of the astragal.

Note 1. p. 506. These corbels are placed at the height of about 33 ft.

Note 2. It is to be desired, that this beautiful edifice be cleared and preserved by a skilful hand, from the ruin that threatens some of its parts, and notably the facade. We shall make known the combination in Art. Construction.

#### CUSTODE. Tabernacle. Pyx.

Thus is called the isolated shrine or a cupboard destined to contain the holy eucharist, the holy oils or the sacred vessels; the same name<sup>1</sup> is also given to the veils, that were designed to conceal the eucharist contained in a suspended case. (Art. Autel). The little ambries made in the walls of chapels, behind or beside the altar, are actual tabernacles. (Art. Armoire).

Note 1. p. 507. In Latin custodia or custodia. (see Du Gange, Gloss., also Art. Tabernacle in Dict du Mob. Franc., etc.



CYBORIUM. Ciborium.<sup>1</sup> Baldachin. canopy.

Note 1.p.508.(Latin note).

This Latin word is employed in French to designate the canopy or shrine, that in certain cases entirely covered an altar. This is what has been designated as a baldachin since the 16 th century. The canopy that covers the main altar of S. P. Peter at Rome is an actual ciborium. At Paris the altars of the Invalides and of the church of Val de Grace are each covered by a canopy in modern style.<sup>2</sup> During the middle ages a canopy was also placed on the tomb of a saint or a person of prominence.

Note 2.p.508. At Nîmes in the church of S. Paul, the architect M. Questel, has erected over the altar a canopy in Romanesque style. In the cathedral of Bayonne, M. Boeswilwald has also just constructed over the principal altar a canopy in Gothic style. At Rome the basilicas of S. Clement, S. Lounet, S. Agnes-w-t-W., etc., are seen canopies placed over the altars, that date from the 12 th, 13 th and 14 th centuries.

The canopy was usually made of precious materials or was covered by sheets of gold or silver.

In France it was not a common custom after the 13 th century to place canopies over altars. (Art. Autel). These were enclosed by columns supporting veils, were composed of a simple table with a suspended tabernacle, but these altars were not covered, while in Italy most of the principal altars possessed a canopy. Yet in France some altars of Romanesque abbey churches had canopies. In the life of S. Odilon, abbot of Cluny,<sup>3</sup> is read this passage:- "He also commenced a canopy over the altar of S. Pierre, and covered the columns with silver plates ornamented by beautiful niello work."<sup>3</sup> Unfortunately we do not possess of those canopies of the Romanesque more than descriptions as brief as this; it is then difficult to give an exact idea of their form, composition or importance. Some Rhenish ivories of the 11 th and 12 th centuries indeed show us canopies over the altars, from which are suspended veils; but these representations scarcely instruct us more than the old descriptions, for these monuments are represented in an entirely conventional manner, they consist of four columns bearing a sort of dome, surmounted by a cross.

Note 3.p.508. Vita S. Odilonis; Abb. inter SS. Bende. Sect 6.



Note A.p.508. Latin note.

It must be stated that unless they assume considerable dimensions, canopies restrict the ceremonial adopted today at the principal altars of important churches. For cathedrals, canopies were ~~contrary~~ to the arrangements adopted in the 12th century, since the bishops, in rebuilding their churches, on the contrary held that the altar should be free, and that it could be seen from all parts of the church.

with respect to the matter.  
 It seems to be a fact that while they were in the  
 country, (somehow) they were in contact with the  
 military, and of course, the military, being  
 the most powerful in the Argentine, is in the  
 position to have a direct, in fact, a direct  
 communication with the military, and that it  
 would be a matter of all sorts of the church.

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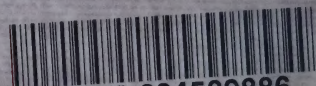








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